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ABSTRACT

The intent of this yearbook is to provide a positive posture for nurturing desirable changes in the status of science teaching. It is written for elementary school teachers and all who are involved or concerned with curriculum and instruction in the elementary school. The yearbook provides the basis for continued professional growth of teachers by stressing ways to logically and realistically infuse science and science-related instructions into schools and to assure that science will remain valued as new patterns of schooling evolve. As a means of promoting science relevancy and literacy, interfaces between science teaching and other areas of human concern are identified and a rationale for encouraging and defending the desired state of science teaching is provided. The book is organized into four parts: providing focus, establishing credibility, exploring interfaces, and discovering applications. Chapters 1 and 2 focus on science teaching and science teaching goals. Chapters 3-5 focus on valuing (1) science content; (2) preparation in science methodology/goals; and (3) the infusion process. Chapters 6-12 address relationships between science teaching and personal/career concerns, children's intellectual development, educational technology (microcomputers) environmental concerns, energy concerns, special education concerns, and cultural concerns respectively. Perspectives from practitioners and on professional growth are addressed in chapters 13 and 14. (Author/JN)

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1983 AETS YEARBOOK

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TEACHING CHILDREN SCIENCE:
CHANGING ADVERSITY INTO ADVOCACY

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
The Ohio State University
1200 Chambers Road - Third Floor
Columbus, Ohio 43212

Association for the Education of
Teachers and Science

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The ERIC Clearinghouse for Science, Mathematics, and Environmental Education is pleased to cooperate with the Association for the Education of Teachers in Science in producing this Yearbook, funded in part through the Center for Science and Mathematics Education, The Ohio State University.

We invite your comments and suggestions on this series.

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Preface

Whereas the focus of the last two AETS yearbooks was on the middle school and the secondary school, respectively, the 1983 AETS Yearbook's exclusive concern is with science instruction in the elementary school. The title of this yearbook reflects its intent--to provide a positive posture for nuturing desirable changes in the status of science teaching. It is especially written for elementary school teachers and all who are involved in or concerned with curriculum and instruction in elementary school education. The 1983 AETS Yearbook provides a basis for the continued professional growth of teachers by stressing ways to logically and realistically infuse science and science-related instruction into schools and to assure that science will remain valued as new patterns of schooling evolve. It identifies interfaces between science teaching and other areas of human concern as a means of promoting science relevancy and literacy. Most importantly, it provides the reader with the perspective and wherewithal to encourage and defend the desired state of science teaching.

This book is organized into four parts, as described in the Table of Contents. Although several approaches to organizing the study of this text are possible, the reader is encouraged to begin with Chapter 1. Ideally this yearbook will be used as a text for teacher development programs, including in-service workshops and college credit courses. Except for previously copyrighted material, all sections of this text may be reproduced without restriction.

Chapters 2 and 6 could be studied together. Both encourage introspection, a re-examination of personal values, and an assessment of "self."

The section on Establishing Credibility attends to developing the affective qualities associated with the topics under discussion. Note that the title of each chapter stresses valuing.

Effective science instruction cannot exist in a vacuum. The interfaces explored in Chapters 6-12 will individually and collectively provide added perspective for the reader. These chapters are substantive and provide supporting evidence for the positions set forth in Chapters 1-5.

The final section of this yearbook represents reflections on the yearbook itself. Chapter 13 provides reactions from elementary school teachers. They provide their views and react to the yearbook as practitioners. Chapter 14 contains guidelines for a more formal study of the yearbook. Teachers are encouraged to use the approach set forth here as a basis for their study of Chapters 1-5. The activities described here could best be used in group studies and are intended to provide teachers with approaches to studying the concepts of this book by applying a variety of learning styles. Specific activities are not provided for Part III although a similar approach is recommended.

There is room for optimism with respect to the future of science teaching in the elementary school. The appeal presented in the 1983 AETS Yearbook is based on reasoned arguments and common sense. Repeatedly, the same arguments are used in different contexts by different authors addressing different issues. This yearbook can do nothing less than encourage and reinforce positive attitudes toward science teaching, yet it can do little more than create a model for change. Advocacy comes not from the pages of a book but from something within us.

Bernard W. Benson

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Yearbooks develop only through the cooperation and contribution of many individuals. The principle tasks before me when I accepted this assignment were to provide a rationale and outline for the yearbook and to coordinate the selection of chapter authors. Both tasks were readily facilitated by the input I received from Hans Andersen of Indiana University, Ernest Burkman of Florida State University, David Butts of The University of Georgia, and Robert Yager and Darrell Phillips of The University of Iowa. I am also appreciative of the assistance of the presidents of NSTA affiliate organizations. These were Betty Burchett of CESI, Gary Downs of NSSA, and Joseph Huckestein of CSSS.

I would like to express my appreciation to all the chapter authors for their cooperation and understanding. I am especially grateful for the contributions of Marsha Cameron, Sheila Jasalavich, and Suzanne Kelly for their work on Chapter 14. They were asked to complete a formative task within a very short time frame.

I am indebted to Jerry Horn who as president of AETS asked me to serve as editor and who provided his support and assistance throughout the project. The ERIC/SMEAC staff and especially Stan Helgeson have provided invaluable assistance and expertise.

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Part I

PROVIDING FOCUS

CHAPTER 1

SCIENCE TEACHING--TODAY'S VIEWS

Doris A. Trojcak

TYPECASTING TEACHERS

Only the proverbial head-in-the-sand ostrich could report that today's view of science teaching in the elementary school is a bright one. Just ask today's elementary classroom teachers. Or, better yet, visit their classes and analyze the results. Classroom visits would most likely reveal the following four different types of teachers:

A. those with approximately 10-25 years of teaching who directly "bought into" the post-Sputnik science education renaissance,

B. those with similar tenure who did not participate in the 60s heyday of science education,

C. those with less than 10 years of teaching who vicariously caught and taught the spirit of the "alphabet curricula," and

D. those with similar brief teaching careers who have been immune to any interest in science education.

Each type of teacher will reflect a different view of today's science teaching since each has experienced a different past. Each group has a different filtering system or focusing mechanism.

The Type A teacher is probably the most frustrated today, yet also the most courageous in "fighting the good fight" in what must at times appear to be a losing battle. This teacher still clings to those favorite Elementary Science Study (ESS) units or Science-A Process Approach (S-APA) modules or Science Curriculum Improvement Study (SCIS) units, patches the tattered kits each year, and manages with improvised material. When the district announces the new science textbook adoption, he or she begrudgingly accepts, whispering, "But I'll still teach my special . . . unit(s)." This teacher experiences a longing for the "good ole days" and an atmosphere of the dynamics which propelled the 60s and early 70s.

The Type B teacher is simply weary, is possibly experiencing the teacher burn-out syndrome, and is caught up in the "back to basics" whirlpool. There is a small sense of guilt associated with the memory that science education was once very important, but this is placated by the rationalization that the 3 Rs are "in" and science is "out."

The Type C teacher is struggling, trying to make science as interesting as possible for the children, but is bothered by the difficulty of accomplishing such an unpopular (and often unrewarded) feat. This teacher lacks that first-hand experience of the Sputnik phenomenon and its subsequent impact on science education. He or she lacks the sense of the imperative that the Type A teacher once had (and, hopefully, maintains somewhat) because the urgent importance of science for children was never directly internalized.

The Type D teacher is very similar to the Type B but with less of the burn-out syndrome and more of the "teach for the test" behavior. Instead of placating a memory of the importance of science for children, this uninspired teacher gives acquiescence to the "basics" (i.e., the 3 Rs) and pacifies the dictates of administrators and/or parents. Science for children is either unknown or ignored for the sake of "accountability."

FACING THE PROBLEM

Even though the categorization of all elementary school teachers into these four groups may well be overly simplistic, a generalization could still be made that science education is NOT the number one priority for the majority from each group. They may share other commonalities, such as less than adequate preparation to. teach elementary science or some degree of fear toward teaching science, but they are more united as being "all in the same boat" of the flagship, "Basics." Spend ample time in their classrooms and the results will eventually emerge that they expend at least five times of their efforts toward teaching reading/language arts and three times toward mathematics compared to the time given to teaching science. Several years ago the situation was "science is that subject taught on Fridays *if* the art projects were completed." Given the present financial crunch and the demise of art education, too, science has often become the carrot or "M-&-M" of the elementary classroom teacher. Too often the statement has been voiced, "If you're good, we'll have science this week." In other words, science is far more like an unnecessary appetizer or dessert than the vital entree. Needless to say, the entree being mandated and served to elementary school children today is that basic menu of reading, writing, and arithmetic. One of the most debilitating realities of today is that children are now on a starvation diet of science. The absence of science from the prescribed basics menu is one of the greatest deprivations made during this decade. The short-term effects are already obvious.

Analyses of the results of test scores from National Assessments of Educational Progress (NAEP, 1978) indicate a strong decline of scientific knowledge and problem-solving ability during the past twelve years. The back to basics movement may be fostering the acquisition of minimal, lower-level skills, but not the attainment of higher-level thinking skills such as inferring, hypothesizing, analyzing, synthesizing, evaluating, and problem-solving. The adoption of mastery learning approaches by numerous school districts has evolved into minimal performance detours away from the main road of developing better thinkers. Learning is being defined as a momentary, mechanistic performance rather than a lasting, internalized, change in capability.

Because of the pressure of covering the basics, little time is now being spent on discovering science. Most of the teachers presenting science lessons to children today have reverted to the dispensing-of-facts approach rather than the inquiry approach. Inquiry requires far more time than the "read the book and answer the questions at the end of the chapter" method.

Time is probably one of the most precious commodities the teacher must guard. More and more has the elementary classroom teacher's day become preoccupied with the "loaded curriculum." Besides the ever-present 3 Rs, and the fading "regulars" of social studies, health, music, art, and P.E., the elementary teacher periodically must deal with drug education, sex education, law education, consumer education, global education, computer education, career education, industrial arts, safety programs, camping programs, home economics, and, perhaps, foreign languages. Many schools also have to deal with programs related to desegregation problems. Besides coping with the "loaded curriculum," the elementary teacher must constantly adjust to the numerous daily "pull-out" interruptions. Throughout the day one or more children leave the classroom for choir, band, remedial reading or mathematics, other compensatory programs, student council, patrol meetings, counseling sessions, individual testing, gifted programs, library assignments, IEP conferences, or sessions in the special education resource room. Let us also not ignore the amount of time the elementary teacher must spend as classroom accountant for such transactions as lunch money, picture fees, insurance charges, or as referee during lunch duty, recess monitoring, or bus director. In many schools where much of the custodial help has been removed, children are expected to clean the chalk boards and erasers, empty the pencil sharpeners and waste baskets, and in general, tidy-up the school premises. Older children are also called upon to serve as teacher aides in the kindergarten and primary grades. Rarely, if ever, does the elementary teacher experience an entire day with the entire class. And rare is the time available for planning and preparing for science lessons, especially if the lessons require materials for the children to manipulate. Small wonder, therefore, that the "hands on" approach of inquiry is now generally "hands off." Little surprise that the Type A teacher is so frustrated, the

Type B so weary, the Type C so overwhelmed, and the Type D so uninspired.

Not only is the elementary teacher's instructional day chaotic and cluttered, so are many of the physical conditions under which he or she must labor. Very, very few schools have a special room for teaching science. Storage space for science materials is at a premium, given the competition from the "loaded curriculum" previously described. Oftentimes, a central area is used, usually an out-of-the-way closet, for the storage of science equipment. But with the release or reassignment of science coordinators to other positions, usually no one is responsible for the refurbishing and/or replacing of the materials. Consequently, an updated, accurate science inventory is another rarity. So is an adequate budget for the purchase of new materials. Mary Budd Rowe (1980) summarized many of the data collected by I. R. Weiss for the National Science Foundation. She reported that very little money is being spent on elementary science materials; more specifically, that in 1977 only 20 percent of the K-6 schools had a budget for science supplies and only 16 percent had budgets for science equipment. Given the trends since 1977, these percentages are probably even lower now. If Reaganomics or a comparable national budgetary process persists, the prospects for improvements are, indeed, quite slim. Presently, approximately three-fourths of the national budget is tied up in what economists call the "uncontrollables"; namely, past obligations for interest, revenue sharing, price supports and other payments to individuals. At least 15 percent of the budget goes to defense and 10-11 percent to nondefense allocations. The total components of education (not simply science education, but all educational endeavors) must presently cope and survive with approximately 2-3 percent of the entire national budget (Klopfer, 1982). The financial crisis in concert with the 3 Rs movement acts synergistically to magnify the negative efforts of both factors.

As more teachers are released because of financial cutbacks or choose to leave the teaching profession for higher paying and, oftentimes easier, jobs, class enrollments are increasing. It is paradoxical that during the present low birth rate period when more manageable class sizes are finally possible, many class sizes are rising. The numbers of children with problems are also increasing. Quite obviously, there's always been a greater generation gap between the elementary teacher and his or her students than for the secondary and college-level teachers and their students. It is generally more difficult to "read the mind" or follow the thinking of a child since theirs is of a different quality than that of an adult's. (Admittedly, this point may well be debatable in terms of the adolescent.) The lives of today's children are significantly different than were the lives of their teachers when they were children. Today's children carry more problems stemming from divorces, child abuse, malnutrition, drugs, alcohol, the detrimental effects of too much TV watching, the decline of strong parental support and supervision, the lack of respect for authority in general, and the pervasive attitude of "take the easy way out at any price." Some parents have relinquished their parenting responsibilities to the schools and have little expectation for more than glorified, painless baby-sitting. The notion that learning requires disequilibrium along with the attitude of caring and valuing is becoming an extinct phenomenon for most children and their parents. A similar commentary may well be directed to principals and higher-level administrators. But they face a different set of problems and pressures.

The convoluted hierarchy of administering elementary education is fairly predictable in its structure but not in its functions. The state commissioners and state boards of education may or may not place pressure on the superintendents in favor of elementary science education. The same is true for the superintendents in influencing their directors of elementary education and their principals and for them, in turn, to influence their teachers. (I know of several schools in which teachers have been sternly instructed by their principals, "Do not teach science; concentrate solely on the basics so our test scores will be better." In some cities, the test scores are actually published in the local newspapers.) We've reached a very sad state of affairs when accountability has become defined only as meeting minimal standards for limited competencies in three subject areas. Yet there seem to be few cries of outrage from another part of the administrative hierarchy, namely, the local School Boards, which consist of elected members of the community. What is their sense of priority other than strategizing how to pass the next school levy? What voices from the concerned community do they hear and heed to improve science teaching today? Surely, an entire community, or state, or nation cannot be posing as a deaf ostrich.

Perhaps another group not necessarily in the hierarchy of administering elementary education but responsive to it is that consisting of science educators or the science "methods teachers" in the colleges and universities who are most responsible for the preparation of the new elementary science teachers. Just as there has been less turn-over among the ranks of tenured elementary teachers, so has there been little infusion of new blood among the higher academic ranks. To what extent do the science educators in higher education realize the real world of the elementary teacher and gear their courses toward improving that world? How great is the gap between higher education and "lower education"?--between theory and practicality?--between clinging to what has been successful in the past or to what is most needed for the present? To what extent do all who are involved in teacher education programs collectively and cooperatively value the importance of science for children? Or is each so myopic that only his or her area of expertise is professed and promulgated? When was the last time those preparing elementary education majors to teach have themselves taught children in an elementary classroom? What is the credibility of their messages, materials, and methods? Perhaps these educators, too, could be categorized as the frustrated Type A, the weary Type B, the overwhelmed type C, and the uninspired Type D. Instead of being caught in the back to basics whirlpool, the latter two types are entrapped in the tenure and promotion snare.

TOWARD A POSITIVE PERSPECTIVE

It is far easier to identify the negatives related to today's views of elementary science teaching than to describe the positives. But the total picture is not entirely dark. It is still too early to judge; but, perhaps, the greatest benefit to be derived from the post-Sputnik birth, maturation, and gradual obsolescence of the "alphabet curricula" is their influence on commercial science textbooks. The present versions are a vast improvement over those from the pre-Sputnik era. Commercial textbook publishers of elementary science series learned well from the mistakes or failures of the National-Science-Foundation-supported "alphabet curricula." The NSF curricula deviated too much from the familiar, from the usual topics and factual approach with which teachers had become comfortable. These programs were far too dependent on unique equipment which, unfortunately, was oftentimes extremely poorly constructed. Balances didn't balance; thermometers had fixed air bubbles; magnets had holding capacities of one paper clip; cylinders were incorrectly calibrated; aluminum wing nut threads had a life-span of 4-6 good twists. The kits were also difficult to store and maintain. The nontextbook approach of the "alphabet curricula" was threatening for the insecure teacher. There was no "Linus blanket" to cling to. When this approach was mandated without sufficient and effective in-service training, the results were often disastrous or, at best, only minimally successful. In some cases, the program was never even tried. (During a show-and-tell of one of the NSF curricula, an experienced teacher exclaimed, "Oh, that's the unopened program that's been stored in the second floor closet for two years.") Or the programs' implementations were short-lived, especially when no assistance and/or follow-up from a science consultant was available. (It's quite strange that science education and accountability have seldom been uttered in the same sentence.) Some of the original versions of the "alphabet curricula" had little evidence of specific instructional objectives and related evaluation techniques. Too often teachers commented, "We certainly had a good time with ... but I don't have a clue what the kids learned from it." The revisions have improved this weakness, but they seem to fit the adage of "too little, too late." Without thorough in-servicing, few teachers clearly understood the various instructional strategies and the psychological/pedagogical framework incorporated in the programs. They could not appreciate either the spirit or the sequence of suggested activities and, consequently, often followed the format in robot fashion or as neutral participants.

The new elementary science programs are back to the textbook format with more of the familiar topics and a better balance between the didactic approach and the discovery approach. They exhibit more intellectual or instructional accuracy than their predecessors. In their older versions, an "experiment" would be presented as "Do this; do that; do this, . . . and here are the results you should get." This cookbook/follow-the-recipe-approach is not quite as prevalent in the newer textbooks. Nor is the dependency on unique, specialized equipment. Quite the contrary, emphasis is placed on readily available and more durable materials from the classroom, home, grocery store, drug store, or hardware store. Kits are still available but more as conveniences than as necessities. Clearer objectives and thorough evaluation techniques are integral components of most of the new textbook series. They are not without fault, however, as sometimes it appears that a different author team was used to write the evaluation program than wrote the book. Reliability, therefore, may still be questionable. But, in general the new texts are easier to follow than the "alphabet curricula" and much easier for most children to read than were their forerunners. They have clearer strategies for average, remedial, and enrichment activities, and are attempting to integrate more social studies, environmental and technological issues, metrics, and mathematics, as well as language arts. It appears that the commerical publishers' response to the "back to basics" in terms of their new science textbooks is a wise one; namely, "If you can't beat 'em, join 'em." But the results remain to be seen. The prevailing negative factors affecting science teaching today still outweigh the positive potential of improved textbooks.

Just what is needed to swing the pendulum back toward the recognition that science is important for children as well as for our society? No one person or group really seems to have the answer. The simplistic solution that we need another comparable Sputnik to spur us into action is probably futile. It is quite paradoxical that 25 years ago Congress responded to Sputnik with the creation of acts to increase funding for science education so that our national security could be strengthened. Now the contrary is occurring: funding is being decreased for science education (and all education) in order to allocate more to defense. Is this not the ostrich's solution for individual insecurity rather than national security? In too many ways, we are surrounded by Sputnik remnants which remain ignored. The U.S.S.R. and Japan, as well as the Eastern and Western European nations are steadily increasing their emphasis on science education. Soviet children, for example, receive 13 years of science and mathematics. We have produced more high-technology military machines than we have soldiers able to operate them. We are headed more toward becoming a scientifically illiterate nation during a period of greatest need for scientific literacy. To what extent are we preparing today's children for the 21st century?--a century which will most likely contain more problems and opportunities related to genetic engineering, nuclear energy, food production, pollution, not to mention all of the unknowns stemming from technology.

First, and foremost, the individual elementary teacher *must* understand, accept, and believe that science is important for children, must realize that children have as much right to understand natural phenomena and be knowledgeable of their environment as they have the right to learn to read, write, and calculate. They have the right to have their innate curiosity about science stimulated and fostered rather than stifled and denied. These understandings must be integrated into the elementary teacher's mentality, but they must also be valued by the principal, the members of the school board, the superintendent, and the rest of the administrative hierarchy.

Science, *particularly* the process or thinking skills of science, must be incorporated as central to the entire "back to basics" emphasis. The purpose of education should be to develop better thinkers; therefore, the thinking skills of science should be the very basis of the basics.

New courses are increasingly springing up to deal with "survival skills for daily living" or "functional literacy." These include such skills as determining the correct change after a purchase, balancing a checking account, determining costs per unit, filling out a form, reading a newspaper, and so on. But think about the potential from a society that has learned to be more observant; that can distinguish observations from interpretations or guesses; that can communicate clearly; that can categorize objects, events, and ideas into meaningful order; that can identify the influencing variables; that can generalize about causes and effects; and that, ultimately, can experiment in search for answers. Think about the potential from a society that practices the ethic of empericism rather than emotionalism or prejudice or any form of objectivity rather than subjectivity. The now defunct Educational Policies Commission once identified seven values in *Education and the Spirit of Science* (1966, p. 15) which characterized the skills of the scientific enterprise and which should be the values of the entire educational process. These were the skills of (1) longing to know and to understand, (2) questioning of all things, (3) search for data and their meanings, (4) demand for verification, (5) respect for logic, (6) consideration of premises, and (7) consideration of consequences. Unfortunately, there is not much evidence that such skills are being included among the "survival skills" in the present basics movement. It is imperative that any return to the basics must include the essential thinking skills which are the means for developing more rational thinkers and better decision makers, not merely minimal survivors in today's world.

Some very serious soul-searching needs to be done. Priorities must be reexamined in terms of:

1. the importance of science teaching in an increasingly technological world and the needs of children to be able to understand science;

2. the amount of time that is or is not devoted to teaching science and how that time is spent;

3. the conceptual appropriateness of the science topics selected for children and the relevancy of these topics;

4. the quantity and quality of in-service science programs available to elementary teachers;

5. the levels of support, both financial and attitudinal, rendered to elementary science education; and

6. the recognition of the importance of the elementary teacher.

Typically and unfortunately, the elementary teacher has been stereotyped as the least esteemed person on the teacher totem pole. Such a judgment is sometimes self-inflicted with comments of, "I'm just a grade school teacher," or influenced by other's, "you're just an elementary teacher?" They are trained as generalists, not specialists, and therefore lack in-depth mastery in a specific content area. Most elementary teachers are expected to teach science yet many have only minimal understanding of science content or of the science processes. Some actually fear science and, regardless of pressure from the 3 Rs will avoid teaching it. All have more lesson preparations and fewer free periods than middle, junior high or high school teachers. Yet, in the pecking-order of who influences whom throughout one's formal schooling, it is the elementary teacher who has the greatest power or, at least, potential power. Children's attitudes toward education are formulated mostly during the early years of schooling. Obviously, the elementary teacher, especially the teacher in the primary grades, can have a most powerful positive or negative influence on the child's attitude toward science education.

Few individuals chose to become elementary teachers because it is an easy job or because they were attracted by the salary and three-month-paid vacation (which is more likely six to eight weeks, given the wind-down and start-up tasks). Most could have specialized in a particular content area but preferred teaching children more than teaching content. Most chose to teach at the elementary level because of their attraction to or love for the elementary school child. They value this child's spontaneity, curiosity, naivete, energy, flexibility, and, most especially, the child's ability to become excited about learning, to enjoy discovering. If they are tired of teaching now, if they are avoiding doing science with children, chances are those childlike attributes are missing from both the children and from within themselves.

SUMMARY

The adversities today's elementary teacher must face will not be gone tomorrow or even in the near future. But one's way of viewing them can change rather rapidly. Science teaching in the elementary grades and curiosity should be synonymous. The root word for curiosity is "cura," meaning care. The key for opening the door to a brighter view is not going to be dropped from the sky. It must come as a result of our own soul-searching, as an intrinsic result of one's real caring. What is present in elementary science education today is a massive state of disequilibrium in the broad Piagetian sense. We've assimilated a great deal of excellent input from the "good old days." What we face now does not fit our past experiences. The energizer for moving us forward and preventing us from slipping farther behind is caring enough to effect the needed changes. Such cannot be mandated by the government, supplied by industry, encouraged by the community, or caused by a school principal. It can only come from the individual teacher. For too many years, educators have tended to separate cognition and affect, the head and the heart. For too long science education has been detached from values, societal concerns, practical usefulness, and children's rights. Caring, now more than ever, needs to be the integrative force. With the personal renewed realization of the importance of teaching children science and the subsequent caring, today's adversities can become tomorrow's advocacy.

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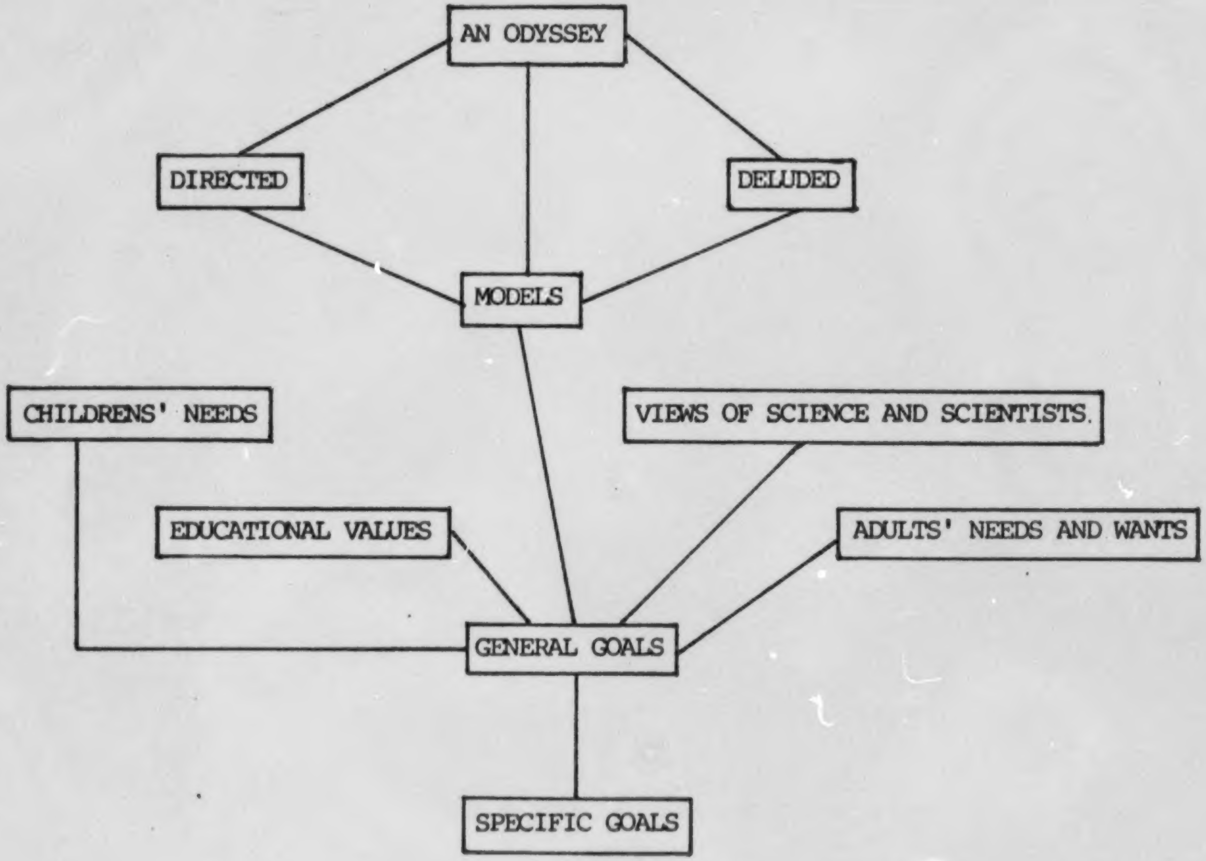
Metaphor for chapter

Perceptions can be

Individual's beliefs

Each person integrates their individual beliefs to form


AN ODYSSEY
DIRECTED
DELUDED
MODELS
CHILDRENS' NEEDS
VIEWS OF SCIENCE AND SCIENTISTS.
EDUCATIONAL VALUES
ADULTS' NEEDS AND WANTS
GENERAL GOALS
SPECIFIC GOALS

CONCEPT MAP: CHAPTER 2

CHAPTER 2

SCIENCE TEACHING GOALS: DIRECTED AND DELUDED

Michael R. Cohen

HOW IS TEACHING LIKE AN ODYSSEY?

Father to son, "David, what are you drawing?"

David, "I don't know Dad, I haven't finished it yet" (Goud,1972).

I wish I could invent a unique statement like David's to open this chapter and have you smile understandingly. But I'm not five years old. I have had many years of schooling and am expected to "know" what will happen whenever I start an activity. Yet, I find David's response more refreshing and much less pedantic than most opening statements. So let me also be less direct and start with a short, commonly heard school problem and then use the problem to provide an overview of this paper. Now remember, this is a serious question. So get ready to think. Here is the problem: "How much is two plus two?"

What comes to mind when you read this question? (Did any of you see or hear yourselves or others asking this exact question?*) Does it seem reasonable or foolish? Do you think there is a trick? How do you get ready "to think"? Before you read on, what is your answer to the question? How many correct answers, in base ten, can you provide? If you can easily provide only one answer, I'll join you and a large number of other teachers who have been so conditioned to answer this question that we just can't think of other correct answers, except possibly twenty-two, which is incorrect. Actually there are many other correct answers: three plus one, ten minus six, two times two, etc.

In this chapter I will consider the following question: Do we teach information like 2 + 2 = 4, which is critical, and think we are providing a broad overall conceptual framework like 2 + 2 = 2 x 2 = 8 ÷ 2? There is no doubt that children must know that two plus two equals four. I am in no way discounting the importance of such a directed aim of instruction. However, the question raised by our overwhelming emphasis on only one correct answer also needs to be addressed. Because we know some answers, have some knowledge within the domain of science, have we deluded ourselves into thinking we also know the proper direction of our science teaching goals?

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* While this question is read, many people can actually visualize, hear, or feel sensations while they are reading. That is, what is received by one sense has the effect of stimulating other senses. This effect is known as synesthesia.

The title for this chapter was suggested by Bernie Benson, when he developed the proposal for this yearbook. When first approached to write this chapter, I was surprised at the title. It was not a point of view I have considered before. However, Benson's title and approach suggested a number of ideas that, at least for me, did not exist before. As I began to organize, the chapter 1 was like David, the artist. I had a vague idea of where I wanted to go, but did not know how to get there or what I would find in the end. That is why I find the term odyssey, used in the next section, so appropriate to describe the continuing development of this chapter and science teaching goals.

HOW CAN DIRECTIONS DELUDE AND DELUSIONS DIRECT?

In the dictionary you will find the following definitions for directed: have authority or control over; manage or guide; instruct to do something; order; proceeding in a straight line without a stop or turn; straight; going from one thing to the next without anything in between. Synonyms include command, manage, and immediate. I think there are science teaching goals to fit each of these definitions. But I do not think these definitions connote negative aspects of our instructional goals. We do have to manage, control, order, and go from one topic to another.

The definitions for deluded include: mislead the mind or judgment of; trick or deceive; to cheat, the hopes of; to elude, evade. Synonyms include beguile, dupe, cheat and defraud. It will be the position of this chapter that many of our directed goals actually delude us. They allow us to think we are causing one effect when, in reality, we are unaware of the consequences. But as with directed goals, it may not always be detrimental to delude ourselves. It may depend more on the effects of the delusions, and on our ability to accept and consider ourselves deluded.

Science teaching goals will necessarily appear directed. We have to make decisions and introduce children to the world of science. But while we appear to be in control of our goals we are also at their mercy. If we are not careful we can delude ourselves into thinking we "know" more than is actually the case. The many terms associated with the definitions of directed and deluded are listed in Figure 1 (for those who will skim this paper). Which, if any, fit your definitions of science teaching goals?

DIRECTED	DELUDED
authority	mislead
control	trick
manage	deceive
guide	cheat
straight	defraud
immediate	beguile

Figure 1. List of terms associated with directed and deluded.

Just as David was not sure what he was drawing until it was finished, we may not know what our science teaching goals will look like in a few years. We may not even know what our goals will look like by the end of a one hour lesson. This ties us in with many scientists who spend a lifetime searching for solutions, and are surprised to find answers appearing when least expected. An interesting example of this is the description of the development of the Wassermann reaction for the diagnosis of syphilis. In describing the search, Fleck says,

> . . . Wassermann and his co-workers shared a fate in common with Columbus. They were searching for their own 'India' and were convinced they were on the right course, but they unexpectedly discovered a new 'America.' Nor was that all. Their 'voyage' was not straight sailing in a planned direction but an Odyssey with continual change of direction (Fleck, 1979, p. 69).

In this chapter I will provide some conceptual islands. The readers are encouraged to combine or rearrange the concepts into their own odyssey.

WHAT IS YOUR MODEL OF MODEL?

There are many educational models or theories one can choose to develop a picture or map of science teaching goals. Each person usually has a particular individualistic view of a "model" classroom or a "model" instructional system. *Model* is also such a common word that we may take its meaning for granted. Since the word "model" is open to many interpretations, the following exercise should help in clarifying its many uses and help us understand the discussion to follow. List ten short phrases or compound words that include the word "model." For example, perfect model, fashion model, model student, current model. Additional answers are included in Figure 2. From the length of the list it is clear that a discussion of this exercise could require the rest of this yearbook. However a brief discussion of a few critical ideas should put this chapter in perspective.

What do models represent? Figure 3 shows two types of models, those that look real and those that act like the real world. The model that looks real is critical for learning names and parts, but it may not provide any idea as to why things work. The model on the right, while it does not look like a real airplane, does actually fly. It can be used to figure out many variables of flight. It is my contention that in education we often opt for models that look real at the expense of models that act like the real world (Cohen, 1981).

But both types of models can delude us. "It is important to remember not to expect the real world to behave (or look) exactly like the model. After all, it is the model that is a copy of the world and not the world that is a copy of the model" (Bunnell and Tait, 1974).

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accurate model
developmental model
follow my model
goal model
model
model airplane
model student
model "X"
model year
partial model
perfect model
preliminary model
temporary model
working model

Figure 2. Partial list of the ways "model" is used in our everday language.

Plastic Scale Model Airplane	**Paper Airplane**
Looks real	Does not look real
Does not fly	Does fly

Figure 3. Examples which represent two types of models: Those that look real and those that act real (after Bunnell and Tait, 1974).

A model is a representation developed by a person to help make sense out of the world. It is only one of many possible representations. Problems arise when people unintentionally think that their job is to remember the one correct and perfect model (Stogdill, 1970).

Analogies are common models used in many science education settings. In order to explain a new idea we present the students with a related example that they understand. We assume that the relationship will be clear and that the student will eventually understand the new concept. Problems arise when the students understand the new concept only in its relationship to the analogy. "A cardinal property of an analogy is that the way it is generated is not the way it is used--obviously. The map-maker and the map-user are doing two different things" (Jaynes, 1976, p. 59). Models built from analogies may only help students reinforce their understandings of the original idea used in the analogy. Or to use the language of this chapter, analogies appear to show direct relationships between old and new ideas. But they may only delude us into thinking these relationships are clear to our students.

Models are critical to science and to education. Their weaknesses and limits should be evident to all who use them. But we have to use them. In fact, within this chapter different types of models, including analogies, are used.

What then are some advantages of using models? According to Linus Pauling, ". . . the greatest value of models is their contribution to the process of originating new ideas" (Judson, 1980, p. 124). Models provide us with opportunities to try our ideas, to see what ideas fit or do not fit and to play with variations. This is very different from the view and use of models in many educational settings. There we present the finished model and expect the student to understand and comprehend. But the student is busy wondering how the model was developed (Stogdill, 1970).

Model building also requires very clear thinking. Pauling continues, "If you have fuzzy, vague ideas, then you can't build a model because a model must be precise" (Judson, 1980, p. 124). This inherent "perfection" of models may delude us into thinking that the real world must follow our model.

These preliminary statements on models express the view I see for models in this chapter. Models are like an airline pilot's checksheet. Whenever a pilot takes off it is a legal and safety requirement to go through the preflight checksheet step by step. It doesn't matter how many times the pilot has flown or how recently the airplane has landed. Each step must be checked to make sure nothing is forgotten. Models in education are our educational checksheets. They tell us what variables are important and help us make sure none are omitted.

According to Carl Rogers, (Frick, 1971) models (checksheets) are most valuable to the person who does the developing. And I think teachers must develop their own models. The remainder of this chapter is a variation on the model of Tyler (1949) used as the basis of the 1981 AETS Yearbook (Ochs, 1981). It does not necessarily look or act like the real world. But it is based on data collected from the real world. It should provide some ideas to think about and should stimulate new ideas, but it is not meant to be memorized. It is my theme and variation on Tyler's model. The ideas, however, will provide parts of a checksheet that the readers can use to evaluate their own science teaching goals and to develop their own appropriate models.

MAPPING YOUR OWN ODYSSEY

The following four sections will provide a number of ideas about children, adults, scientists and educators. A chart is provided in Figure 4 that you can fill out as you read and think about the ideas. Most items in the chart are introduced or discussed in one or more of the sections. By filling out the chart you can relate the ideas presented to your own views. You are developing your own checklist and building your own model. You are encouraged to add items to the chart, redefine the items already included, and attempt to integrate the chart into your view of science teaching goals.

	CHILD	ADULT	SCIENTISTS	EDUCATOR
MAJOR ROLE PLAYED BY . . .				
MINOR ROLES PLAYED . . .				
TIME CONSTRAINTS	speed kills	speed all	need time	worried about time
IMPORTANCE AND TYPE OF MEMORY				
SHORT TERM				
LONG TERM				
INTEGRATED				
IMAGINATION				
DEFINING PROBLEMS				
FINDING PROBLEMS				
SOLVING PROBLEMS				
MAKING ERRORS				
EGO DEVELOPMENT				
DEALING WITH CONTRADICTIONS AND AMBIGUITIES				
FOLLOWING INSTRUCTIONS				
INTERPRETING DATA				
VALUE OF INFORMATION				
MOTIVATION				
OUTLOOK ON LEARNING				
STUDYING				
OUTLOOK ON TEACHING				
FAITH IN "SCIENCE"				
FAITH IN "PEOPLE"				

Figure 4. List of variables relevant to our stereotypes of children, adults, scientists and educators.

Let me provide an example of how I found Figure 4 useful for thinking about, and relating my ideas to, the four categories. I'll use the example of time constraints and list how I see time constraints generalized for each group. The underlined material represents what would be listed in the appropriate boxes on the chart. Of course the few words (underlined) are shortened from the longer conceptualizations. Children: Speed kills ideas and learning. When children rush they usually overlook the obvious. They need time to internalize ideas. They can also get lost in activities or ideas and forget about time. Adults: Time is critical and speed is often all that is important. Are you in a rush to finish this chapter? Scientists: Need time to think about ideas and try things out. Scientists do not take timed tests. Educators: Too worried about time. Many of us are under pressure to "cover the material."

Tyler's model (1949) developed objectives by screening input from society, students, and the subject matter through philosophical and psychological theories. The parameters of this paper include input from students and the subject matter, but I believe the ideas are different from those of Tyler. In addition, what Tyler calls the input from society may be included under the categories, adult and educator. However, I am more interested in how we behave in our environment than in listing the goals as they relate to society.

Rather than propose a psychological or philosophical position, this chapter asks you to personalize your attempts to develop understandable science teaching goals that students can assimilate and accommodate by posing the following three questions.* How does your perception of the items you include in each of the areas increase the probability of developing meaningful and appropriate science teaching goals? How does your intepretation of the items on the chart increase the probability that you can express the science teaching goals in an understandable manner? How does your integration of the ideas in the chart lead to science teaching goals that increase the probability of students assimilating and accommodating the science concepts?

I assume that you are all familiar with the fact that most children draw stereotypical pictures of "scientists." They picture the scientist as a bearded male with long or wild hair, wearing a white coat and usually in a laboratory with test tubes and bubbling flasks. As you read the following four sections, a little synesthesia should help put the ideas into perspective. That is, try to imagine the picture of a scientist, a teacher, a child and an adult conjured up by the ideas. Are the images stereotypical? Are the images close to your "models?" How do these images help you fill in items in Figure 4?

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* Prince (1970) uses this type of question to describe effective problem-solving behaviors. Rather than asking if the behavior is good or bad, he asks whether it increases the probability for successfully solving the problem.

WHAT STEREOTYPE OF CHILDREN DO WE USE TO DEVELOP SCIENCE TEACHING GOALS?

It may seem obvious that elementary school children are not high school or college students. But it is often difficult to distinguish between the first grade and the college science class with respect to the content covered, the explanations given, the methods of instruction used, and even the pictures in the textbooks. The students do not always learn progressively more complicated and expanded concepts as they become older. They seem to be presented the same material over and over again. And despite this repetition, students still reach adolescence and adulthood with many incorrect science concepts (Cohen, 1982; Novick and Nussbaum, 1981).

What then are the perceived roles we envision for children in an elementary school science class? It is easy to say we must meet their needs. But who determines those needs? What needs could justify goals that do not appear to substantially change the science classroom over a period of 14 years?

In viewing the roles of children, I would like to make a distinction between necessary, and necessary and sufficient. We can identify many variables that are necessary to children's scientific development. However, we often take these necessary components and treat them as if they are necessary and sufficient. That is, all you have to do is . . ., and children learn science without any problems. In an effort to reassure the reader that when I present only two ideas related to science teaching goals for children as if they were necessary and sufficient, the reader will know that I am aware that the problem is more complicated. However, in the interest of time and space, and with an awareness that we can only hold a limited number of variables in our minds at the same time, I choose to select two ideas that I feel are critial, perhaps even necessary and sufficient, for developing science teaching goals.

I believe it is a valid science teaching goal to try to help children move from what Piaget called the concrete operational level to what he called the formal operational level. Many of our science activities, which include cognitive, affective, and psychomotor components, can help children make the transition over the elementary school years. I am not interested in speeding up development or in trying to mimic formal operational behaviors. It is just that science education can provide the arena in the elementary school where children can experience the limits of concrete operational behavior. I am aware of the fact that, while the goal of attaining this higher order cognitive ability is important, there is no guarantee that formal operational thinking leads one to maintain only correct scientific concepts. It is likely that many scientists from the past did think at the formal operational level while maintaining scientifically incorrect concepts.

I will therefore not delude myself into thinking that once every child leaves the elementary school as a formal operational thinker, he/she will automatically be able to clearly comprehend science. But it is interesting to see how an acceptance of this view of a science teaching goal affects one's perceptions of the roles of children in an elementary school class. After completing this section and reviewing the list provided in Figure 4, I tried to see how I related each item to a child if I thought one of the goals was to help the child achieve the formal operational level. I would suggest you review Figure 4 before reading the next section. What would a stereotypical child (or teacher) look like if the science teaching goals were focused on fostering development of formal operational behavior?

A different set of components of science instruction at the elementary level, and possibly a different set of stereotypes of the elementary school child, are provided by studies of children's science concepts using adaptations of Piaget's clinical interviews (Pines, et al., 1978). These studies provide the basis for "developing a firm knowledge about the existing beliefs and commitments of children in selecting content areas" (Erickson, 1979, p. 221). Such "research area of exploration" for developing goals related to the needs of both children and schools (Gallegos, 1981, p. 38).

Figure 5 provides a list of statements given by children as they tried to explain a variety of science concepts. The content of children's explanations provide one useful set of information for teachers and curriculum developers. As described by Posner and Gertzog (1982), interview studies can also sensitively address a number of cognitive features related to children's attainment of science concepts. They propose six features that are clearly indicated by interview studies and should help us understand how children reach and maintain science concepts.

1. Students avoid making basic conceptual changes by maintaining a separation between science and the

real world, in spite of the impression that they have "learned" the material.

2. If the instruction does not fit their basic concepts, students resist changing their conceptual schemes.

3. Students find many science concepts difficult to accept because the concepts are apparently counter-intuitive.

4. Since we claim that all of a student's current theories and concepts are the results of changes in prior notions, it is of utmost importance to identify and represent a student's current conceptual schemes before attempting to predict subsequent schemes.

5. If previous schemes are firmly established, students try and fit the new ideas into their existing frameworks.

6. Students often mix faulty basic assumptions and/or faulty reasoning to reach correct or incorrect ideas (Posner and Gertzog, 1982).

The responses provided by the children in Figure 5 may bring smiles to adults. Art Linkletter (1965) took advantage of this humor when he brought children's "funny" responses to the attention of the country. But why do we smile? Why did Art Linkletter's interviews surprise us? If adults, including teachers, really listened to children, the "funny" things children say would not be considered unusual. We would have been aware of them all our lives.

The smiles and surprise represent one adult perception of children. But some people perceive other alternatives. Driver and Easley (1978) propose that students develop "alternative frameworks" to make sense out of the world of science. Cohen and Kagan (1979) have proposed a related term, "mixed-conception," to describe children's seemingly incorrect responses. Both of these terms were invented from a perspective that was respectful of children's ideas. They suggest that children are trying very hard to think about their answers and to make sense out of the world. Their incorrect ideas are not always misconceptions, which imply there is something wrong with the children, but "alternative frameworks" and "mixed conceptions," which imply an attempt by the child to understand the world and science concepts.

"We have a water cycle in our washing machine."

"We rent water cycles and pedal around Lilly Lake."

"Clouds get hot and sweat. Then it rains."

"Eye glasses do the eye's work, because the glasses can't close their eyes."

"You have two eyes cause one would look funny."

"Salt in the oceans is caused by pollution."

"The earth is a place we don't live. We live here."

"Birds fly south to hibernate."

"The sun is bigger than the earth because it has to light half the earth. If it was smaller than the earth it couldn't do it."

"To find the size of the sun and the moon you look through a microscope."

"Why did the wind stop breathing?"

"Blood only moves when you do something."

"Clouds float inside the sky when they go away."

"When animals awake from their long winter nap the first thing they do is stretch and yawn."

"The sun doesn't shine in the winter."

"The sun burns your eyes more during an eclipse."

Figure 5. Children's explanations of a variety of science concepts.

A second valid science teaching goal then is to help children develop science concepts that are generally acceptable by understanding the difference between their own ideas and those of "official" science (Nussbaum and Novick, 1981). "If the conceptual change process is to be rationally based, then students will need to be immunized against the kind of inevitable indoctrination that occurs when neither the teacher nor the student is aware of his/her own fundamental assumptions, much less those implied by the science she is teaching and learning" (Posner, et al., 1982, P. 224).

The student is therefore an excellent source for determining students' needs. A review of Figure 4, with a respectful perspective for students as such a valid source, can stimulate ideas that may begin to provide an "immunization."

CAN ADULTS SEPARATE SCIENCE TEACHING GOALS FROM INDOCTRINATION?

> Ideally, man should remain receptive to new stimuli and new situations in order to continue to develop. In practice, however, the ability to perceive the external world with freshness decreases as the senses and the mind are increasingly conditioned in the course of life (Dubos, 1968, p. 139).

In our attempts to help children understand science concepts, it may be reasonable to begin with their already existing belief systems. The previous section could be considered an extension of Ausubel's famous dictum, "The most important single factor influencing learning is what a learner already knows. Ascertain this and teach him accordingly" (Ausubel, 1968 p. vi). This section suggests that we rewrite Ausubel's statement as it relates to the educational community. That is, what do educators perceive their most important role to be. Ascertain that and you will be able to understand how they perceive and develop their science teaching goals.

Children are not the only people with their own "system of concepts and symbols which constitute a map of reality" (Capra, 1975). As adults we also have developed maps which represent "only some features of reality: we do not know exactly which these are, since we started compiling our maps gradually and without critical analysis in our childhood" (Capra, 1975).

> When we are gradually transformed into the elders and betters, all but a few of us forget or write off our ability for great achievement. We make a virtue of adult consistency and rigidity; we diminish our ability to grow and change; we find that while our eye was on imitating adulthood, we have let slip our grasp of

> originality. We need to rediscover how to change so as to renew our ability to solve problems in original, satisfying ways rather than persisting in imitation and passive acceptance (Prince, 1970, p. 1-2).

In order to "rediscover how to change" we first have to accept our present positions, understand how we arrived at them, and realize the difficulty of changing. One reason teachers approach science teaching goals from a directed position is that they know the answers the children are to learn. Being older, having experienced instruction in the past, we know where we are going. It is difficult to see that we are often deluding ourselves.

There is one major difference between interviewing children and adults to obtain an idea of their science concepts. The adults are more afraid of making a mistake. They know many sophisticated and polite ways to deflect questions. They can become humorous to avoid a direct answer (all examples of delusions.) Adults exhibit many of the features described by Posner and Gertzog (1982) as they try to pretend they "know" science. For example, they use their "authoritative" adult voice to express a counterintuitive science concept that they don't actually believe, but "know" from reading a book. And the longer they repeat such concepts the more they delude themselves into believing they truly understand the concept. These delusions eventually turn into directed science teaching goals. This may not be entirely their fault. It may be the result of our attempts to "simplify" science.

> Popular science in the strict sense is science for the non-expert, that is, for the large circle of adult, generally educated amateurs. It cannot therefore be classed as introductory science. Normally a textbook, not a popular book, is used for the purpose of introduction. Characteristic of the popular presentation is the omission both of detail and especially of controversial opinions; this produces an artificial simplification. Here is an artistically attractive, lively, and readable exposition with last, but not least, the apodictic valuation simply to accept or reject a certain point of view. Simplified, lucid and apodictic science--these are the most important characteristics of exoteric knowledge. In place of the specific constraints of thought by any proof, which can be found only with great effort, a vivid picture is created through simplification and valuation. . .owing to simplication, vividness, and absolute certainty (this popular science) appears secure, more rounded, and more firmly joined together. It shapes public opinion as well as the Weltanschauung and in this form reacts in turn upon the expert (Fleck, 1979, p. 112-113).

The most difficult part of this section revolves around the terms we, us, and they. It is easy to imply that we are not afflicted with the same problems of perception as others. But in reality, most of us have been acculturated within the same system. Within the wide range of alternatives available, even those on the fringes are aware of, and affected by, the "mainstream" ideas. That is one reason why so much of science and science teaching goals appear so directed. And that is why the ideas of this section and those expressed in the following two sections may be difficult to accept. They require each of us to attribute to ourselves the best and worst we see in others.

The difficulty of changing, however, should not prohibit us from trying. One useful way to try to change is to consider teaching science similar to teaching a card game. When I taught my son to play rummy he won his first game with four aces and three kings. However, if he continued to play future games and expected to win with the same hand, I had not taught him to play rummy. I had taught only one possible winning hand. He had to learn to wait until the hand had been dealt before setting up his goal and the playing rules. I think the same is true for science teaching. Our science teaching goals need to be open enough to take into consideration our own and our students unique "hands." If we can make a concerted effort to obtain and maintain an openness toward the idea of these "hands," I think we would develop more meaningful science teaching goals.

Mead (1970) has described differences between children and their elders that are similar to the ideas expressed in this section. She indicates three types of situations, present in the world today, within which adult-child interactions occur. In the first type of situation, usually occurring in pre-industrial societies, younger people learn mainly from their elders. In more industrialized societies parents and elders may not have the skills to help younger people learn to cope with the fast changes. In these industrial societies, younger people learn mainly from peers and/or specialized experts. In the third type of society, where change occurs very quickly, elders may have to learn from children. It is not that children have the skills for solving problems. But they do have a different perspective about what problems are important.

In some respects, the development of science teaching goals fits these three categories. There are goals which "elders" believe are critical. In those cases the elders choose the goals and teach the students. This is probably the main model for education perceived by most people. But, as with the other types of societies indicated by Mead, there are other situations. Peer instruction, group or committee assignments, and science fair projects could be considered examples where "elders" have less importance and input into the instruction. In a manner similar to the industrial society, these instructional settings can work with little input from instructors.

The third type of society described by Mead may be closely approximated in the educational world by doctoral programs. In those situations the students actually do the leading. They often select topics unknown to their mentors. The mentors still play a critical role, but more as a source of help when needed than as the planner, leader, or guide.

In this section I have tried to indicate some problems faced by adults as they develop science teaching goals. It is possible that the major problem is the idea that we have gone through a particular "model" of schooling and have a difficult time imagining other approaches. The point of this section is to ask us to try to plan our science teaching goals for the three types of situations described by Mead (1970). Some of our goals will be selected and planned by adults, but others need to be planned in cooperation with the students and some must be left entirely to the students.

This is an appropriate time to return again to Figure 4 and see how each item is considered if we try to integrate our adult images and approaches with student enthusiasm and inquisitiveness. What types of adult stereotypes are needed to plan the science teaching goals for each type of learning situation?

HOW ARE YOUR STEREOTYPES OF SCIENCE AND SCIENTISTS RELATED TO ADULTS, EDUCATION AND CHILDREN?

Children draw stereotypical scientists. But adults' ideas of science and scientists may not be any less stilted. Figure 6 lists six different but complementary views of science. Which do you agree with? Which would you change? Which do you think are wrong?

The question of evidence, of knowing answers, was raised in the previous section on adult perceptions. Those perceptions apply equally to our view of science. In fact, a look at scientific evidence, at knowledge, may be the place to begin a view of science and scientists. Discussing the process he used with James Watson to determine the structure of DNA, Francis Crick says:

> The point is that evidence can be unreliable, and therefore you should use as little of it as you can . . . I mean, people don't realize that not only can data be wrong, in science, it can be misleading. There isn't such a thing as a hard fact when you're trying to discover something. It's only afterwards that the facts become hard (Judson, 1980, p. 169).

What concepts would you fill in for the items labeled value of information, faith in science, making errors, following

Science can be defined, if you want to, as a technique whereby uncreative people can create and discover, by working along with a lot of other people, by standing on the shoulders of people who have come before them, by being cautious and careful and so on. (Maslow, 1971, p. 60).

The scientific view itself is culture bound--one possible perspective among many. (Tuan, 1974, p. 5).

The real purpose of scientific method is to make sure Nature hasn't misled you into thinking you know something you don't actually know. (Pirsig, 1974, p. 100).

Traditional scientific method has always been at the very best, 20-20 hindsight. (Pirsig, 1974, p. 273).

. . . the scientific approach to all problems carry out theoretical and empirical analysis of the process in a manner that is subject to criticism and that provides cumulative knowledge. (Hammond and Adelman, 1976, p. 390).

When most people say 'scientist,' they mean 'technician.' A technician is a highly trained person whose job is to apply known techniques and principles. He deals with the known. A scientist is a person who seeks to know the true nature of physical reality. He deals with the unknown. (Zukav, 1979, p. 36).

Figure 6. Six examples of the "concept" of "science."

instructions, and dealing with contradictions and ambiguities in Figure 4 if you wanted to support this view of Crick? What beliefs of science and scientists would you have to change?

While I will treat science as a separate item, I do think our perceptions and conceptions of science determine our view of science teaching, and our view of science teaching determines our view of science. We do, however, have to try and keep them separated so that we can see how each affects the other. In discussing our view of scientific knowledge, facts, and truth, we have to understand the difference between a scientist's view, such as Crick's above, and the view of teachers. For example, as soon as your colleagues find out you "teach science" you become the "scientist." "Help my child with an idea for the science fair," becomes a tame question. You have probably been asked more complicated and difficult questions. The point is that people think because you teach science you know lots of scientific information. And scientific information is viewed as "truth." Contrast that view held by many teachers with the following view of "scientific truth."

> So much for the relationship between the 'truth' of a scientific assertion and the nature of reality. There isn't any. Scientific 'truth' has nothing to do with 'the way that reality really is.' A scientific theory is 'true' if it is self-consistent and correctly correlates experience and, therefore, it is useful. If we substitute the word 'useful' whenever we encounter the word 'true' physics appears in its proper perspective (Zukav, 1979, p. 287)

It is difficult for us to overcome this confusion of science with knowledge. But it may be more of a mistake to presume that scientific information can be used to motivate children to study science. It is possible that our emphasis on scientific knowledge, and even on scientific processes, may not represent an accurate view of science or provide people with reasons for studying science. Maybe what is most exciting about science to a scientist is not knowing when you go to sleep if your field of study will change by morning (Thomas, 1982). Can we integrate our view of science as knowledge with this openness? Thomas thinks so.

> On any Tuesday morning, if asked, a good working scientist will tell you with some self-satisfaction that the affairs of his field are nicely in order, that things are finally looking clear and making sense, and all is well. But, come back on Tuesday, and the roof may just have fallen in on his life's work. All the old ideas--last week's ideas in some cases--are no longer good ideas. The hard facts have softened, melted away and vanished under the pressure of new hard facts. Something strange has happened. And it is this very strangeness of nature that makes science

> engrossing, that keeps bright people at it, and that ought to be at the center of science teaching (Thomas, 1982, p. 91).

I hesitate to ask you to return to Figure 4. But I found when working on this chapter that it helped me tie together the various ideas brought up in the previous two sections with the ideas of science and scientists just expressed. In reality, children may be more like "scientists" than are adults. That has often been the case when referring to Einstein (Zulav, 1979). How can we develop science teaching goals that use the strengths of children to develop the needed skills of scientists?

HOW DO WE DEVELOP OUR IDEAS ABOUT SCHOOLS AND TEACHING?

> ". . .faith and doubt belong together. . .they govern each other like inhaling and exhaling. . ." (Hesse, 1970, p. 119).

Education is a strange mixture of faith and doubt. On the one hand it relishes the past. Nostalgia is very powerful. It may be one reason "back" is the first word in that alleged movement for excellence called "Back to Basics." But we must doubt our faith in the past because, on the other hand, every school district is proud of its latest new building, planetarium, computer, or other "innovation." American education may be nostalgic but it is never out of style. Programs, planning, curriculum, almost all aspects of a school district's responsibilities, can change as rapidly as the latest fad.

Against this mixed backdrop of stagnation and revolution, it is difficult to know how to approach a "current" consideration of science teaching goals. That may be why, as described earlier, science education may look the same from preschool through the university. Nostalgia seems to win out, at least some of the time. In this section we may find ourselves in a position analogous to that of other students/professionals.

> In 1922, Werner Heisenberg, as a student, asked his professor and friend-to-be, Neils Bohr, 'if the inner structure of the atom is as closed to descriptive accounts as you say, if we really lack the language for dealing with it, how can we hope to understand atoms?' Bohr hesitated for a moment and then said, 'I think we may yet be able to do so. But in the process we may have to learn what the word understanding really means.' (Zukav, 1979, p. 219).

I am not so presumptuous as to believe that I can easily improve my own or your definition of understand. I can only provide a number of observations and ideas that will help you review, again, the items in Figure 4.

This section is intimately related to the section on science. As described in that section, one's view of science dictates one's image of scientists and,

> . . .the 'scientist' of school science is revealed as a depersonalized and idealized seeker after truth, painstakingly pushing back the curtains which obscure objective reality, and abstracting order from the flux, an order which is directly revealable to him through a distinctive 'scientific method' (Cawthron and Rowell, 1978, p. 32).

This is a view of science that I do not think accurately describes the scientists evident in the previous section.

In addition, the "scientific method" is thought by many to be used to logically organize instruction so that students will have no problems understanding science concepts. An excellent example of the falsity of this idea is evident in the research of Bilbo and Milkent (1978). In most attempts to teach volume it seems logical to start with measurement of length, then move on to area, and, finally, after logically progressing through preliminary stages, to approach volume. But it turns out that the logic of the preliminary activities does not help students understand volume. "The results of this study support the position that it is not necessary to progress sequentially from linear to square to cubic units in teaching metric units of volume" (Bilbo and Milkent, 1978, p. 35).

Our experiences in school, and our roles as students, teachers, and adults, combined with our images of scientists, provide us with a clear picture of science teaching goals. They are logically developed and implemented. But, the concept of vaccinations was counterintuitive when first "invented," and required scientists and the general public to reevaluate their idea about controlling diseases. I believe we have to reevaluate our images of the roles played by teachers and the curriculum. Many of our ideas, such as the teaching of such a seemingly simple subject as volume, may need counterintuitive approaches. And an acceptance of the place of counterintuition may be one of the variables Bohr alluded to when he mentioned understand.

It is difficult to accept the fact that any of us would discount any ideas simply because they were counterintuition. That was a problem Posner and Gertzog (1982) attributed to children. But consider the following suggestions by Lewis Thomas, chancellor of Memorial Sloan-Kettering Cancer Center.

> I suggest that the introductory courses in science, at all levels from grade school through college, be radically changed. Leave the fundamentals, the so-called basics, aside for a while and concentrate the attention of all students on the things that are not known. You cannot possibly teach quantum mechanics

> without mathematics, to be sure, but you can describe the strangeness of the world opened up by quantum theory. Let it be known, early on, that there are deep mysteries and profound paradoxes revealed in distant outline by modern physics (Thomas, 1982, p. 92).

He continues by suggesting we bypass the practical and profitable aspects of biology to raise questions about the strange "creatures" in our cells. How do they produce and use the energy needed for life? Ecology should be taught early on, not only because it is critical to our survival but because it provides "something to think about." Finally he suggests that we downplay the promises of a better life through science. ". . .technology is far from the first justification for doing research, nor is it necessarily an essential product to be expected from science." (Thomas, 1982, p. 92).

Thomas presents a set of science teaching goals from the point of view of a research scientist. How is it different from the point of view of a teacher? If you will review the quote from Fleck, in the section on adults, you will notice that Thomas is describing introductory science, not popular science. I feel he is saying curiosity is what makes science exciting, not just a lot of facts. Of course, I do not think Thomas is discounting the place of knowledge in science instruction. It is just that it is not always the best place to start instruction. It may be your final goal, but how do you get there, and how do you want the students to perceive that knowledge? If knowledge is taught as always being subject to change, it will still be important but will not be critical. That is, you may more readily accept changes in ideas and knowledge if you understand that all knowledge is tentative, even when presented in an absolute manner.

As you read about these views of science teaching what would you picture right now if asked to visualize an elementary school science lesson? Where do you picture the lesson taking place? Who is talking? Who is manipulating materials? Who is asking questions? Is the setting more like a classroom or more like a laboratory? It is important to accept the idea that ". . . sufficient data do exist to suggest that laboratory instruction may play an important part in the achievement of some (science teaching) goals" (Hofstein and Lunetta, 1982, p. 212). Our concept of a laboratory may need to be expanded. It could be in the woods, along a shore, or just sitting in a chair. It may or may not involve manipulation but it should involve wonder.

Since the 1960s science education programs have tried to reach some additional laboratory-type goals by an emphasis on science process skills. These process skills are now a legitimate and critical part of science education. The question is, have they improved our ability to teach science? Have they increased students' interest in science? Taken at face value, it does seem reasonable to teach students in a science class the same skills of observation, prediction, controlling variables, etc. used by scientists. But it does not automatically follow that if the students learned these skills they will understand the overall process and content of science. Nor will they see the value of these skills in learning science. And that is the point I think we need to to address.

In many settings, process skills are seen as the opposite of, or in opposition to, science content. In other settings the process skills take on the context of science content. They are easily misinterpreted. For example, many teachers and students confuse observations with facts. They think if they see it, it must be correct. Inferences are thought of as wild or blind guesses. Predictions are seen as ideas that must come true. Controlled variables are taken to be those variables you have direct control of at all times.

These misinterpretations are only one problem with science process skills. If they are seen as being the opposite of content, they are taught separately. They are not, however, individual skills isolated from content. They are more than a list of procedures scientists follow when conducting research. They provide a variety of ways to conceptualize and more fully understand content. Each process provides a unique way to help scientists, and students and their teachers, develop science concepts. Inferences, for example, help scientists come to conclusions about ideas and are not only used to see what the evidence at hand implies. Inferences are used to develop hypotheses not only to discuss the results of testing some hypothesis. Inferences are a way of putting science concepts together.

Science process skills widen one's repertoire of learning skills. They allow students to conceptualize science from different points of view and different paths. And the greater the variety of senses and approaches one uses, the better concepts are understood and retained.

This section is titled, "How do we develop our ideas about schools and teaching?" Its aim was to have each of us look at some overall ideas about education, since these overall ideas directly affect our attempts to develop science teaching goals. In looking at the development of some of our ideas, it is clear that our past experience has an important role to play. But it is suggested that if we look at the past, and see how it takes on the inappropriate power of being correct (i.e., the only way to do things) we should be able to look at some counterintuitive ideas from a more "common sense" point of view. Try to approach the items in Figure 4 from a counterintuitive point of view. How can a counterintuitive point of view open up new science teaching goals?

HOW DO YOU SUMMARIZE AN ODYSSEY?

An odyssey may have no real end. In a similar manner, there is really no end to a discussion on science teaching goals. Fortunately, deadlines cause you to stop and try to summarize your position. How can you put together the many diverse points and opinions discussed in this chapter? One way is to use a method similar to that used to confirm a hypothesis. According to Martin (1972) there are "four factors" used to confirm a hypothesis: "(1) amount of evidence, (2) variety of evidence, (3) precision of evidence, and (4) indirect theoretical support," (Martin, 1972, p. 26). As you integrate the ideas into Figure 4, how do your choices relate to these four factors? What amount of evidence makes you feel comfortable? What variety of evidence do you feel is needed to justify your position? How precise do you require your evidence to be? Into what theoretical frameworks do you require your evidence to fit? In determining your science teaching goals it would appear that you must consider all of the many different points of view and opinions expressed in this chapter against each other and against Martin's four factors. But nothing could be further from the truth. The views expressed in this chapter have to be confirmed by each individual teacher, possibly using the four factors. From the many, you have to select a few that you can handle and that can be applied to your situation. When there are many choices you need to be aware of all and yield to the evidence, but also be aware of the

> . . . danger that this yielding to evidence may degenerate into unwarranted vacillation. It is not always possible for the mind to balance evidence with exact equipoise, and to determine, in the midst of the execution of an enterprise, what is the measure of probability on the one side or the other; and as difficulties present themselves, there is a danger of being biased by them and of swerving from the course that was really the true one (Chamberlin, 1965, p. 758).

During an odyssey you may wander around in an aimless manner. You may vacillate, go where the winds blow you. But when you return home, you may tell a story that sounds like you were in control all the time. You always knew where you were going. In some respects that is how I view science teaching goals. You start out in one direction, but on the way you are swayed by input from your students, current events, novels, the weather, etc. You are like David when he began to draw. When you are finished you may have a clear picture, but to pretend that you knew about this picture before you started is not entirely true. But, if you can continue to learn from each picture you finish, future pictures can be more interesting and more carefully planned.

This chapter began by asking you to answer the question, how much is two plus two? If you were asked to answer that question again, could you provide answers that were different from those suggested earlier? Let me suggest some. Two plus two could be any number if you are talking about the real world. If you had two pairs of rabbits the final answer should be much greater than four. The rules, the directed rules of mathematics, have to be considered within the real world. It may cost one dollar to buy a dozen eggs and ten dollars to buy ten dozen. But if you bought ten thousand dozen it would not cost ten thousand dollars. Surely you would get a break.

Science teaching goals will continue to appear directed and they will continue to delude us into thinking we are doing the best job possible. We need to be able to admit our weaknesses and be more open to real changes. ". . . the chief glory of the past was its triumph over the age that came before." (Dyson, 1979, p. 36). Let's hope that the chief glory of our present and future science teaching goals will be their triumph over the past.

Appendix

It may be expected that a chapter on science teaching goals should end with a list of those goals. But many lists are available elsewhere. A good source is the previous AETS Yearbook (Ochs, 1981). A recent list which appeared as an editorial in Science seems to capture the spirit and content of the chapter. It is included here as Figure 7.

I suggest that we seek to provide experiences to enable the student to accomplish the following goals:

To discover and explore scientific phenomena.

To have some experience with the scientific approach to the rationalization of the results of investigations.

To develop some understanding of the integrity of the process of scientific investigation and through that the integrity of scientific knowledge.

To develop some understanding of the process of technological innovation and of the productivity of technology.

To explore the impact of scientific knowledge on the manner in which we perceive ourselves and on our relations with others and everything that surrounds us.

To explore the impact of technology and the products of technology on the quality of life and the quality of the environment.

To develop the interest, competence, confidence, and will to continue to follow, throughout the next half century, scientific and technological developments in areas related to societal concerns.

To develop the will and confidence to endeavor to participate critically in the formation of decisions in societal matters involving science and technology.

To develop, in some degree, an understanding of probability and statistics and the place of both in science and in the analysis and resolution of societal problems.

To develop familiarity with the role of computers in the extension of scientific knowledge and technological capabilities.

To develop the confidence to acquire competence in specific areas of technology closely coupled to the fulfillment of his or her professional responsibilities.

Figure 7. List of goals of science education included as part of an editorial by Anna J. Harrison appearing in Science, Volume 217, p. 109, July 9, 1982. Copywright, 1982, by the American Association for the Advancement of Science, reproduced by permission.

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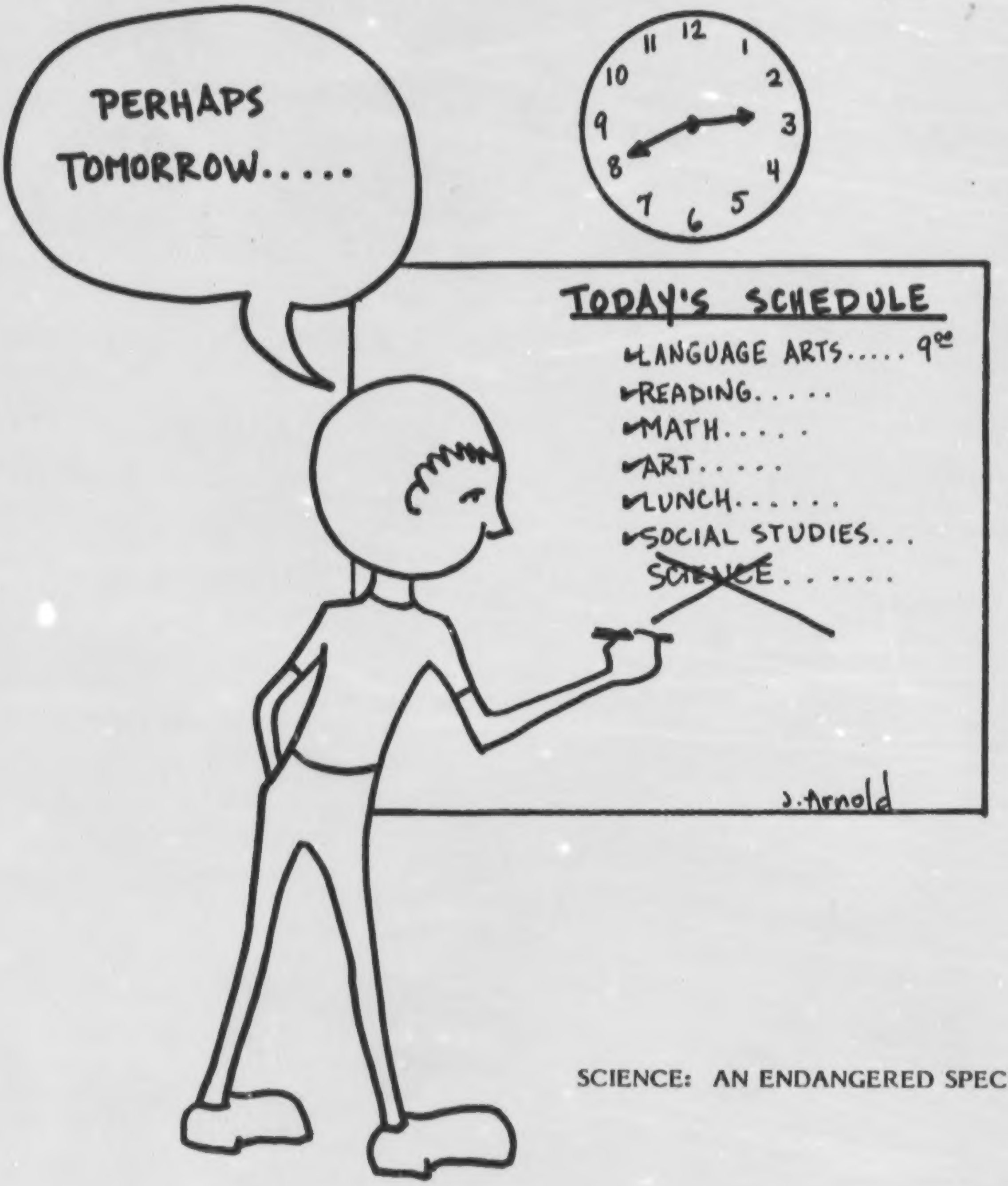
PART II

ESTABLISHING CREDIBILITY


PERHAPS TOMORROW.....
TODAY'S SCHEDULE
LANGUAGE ARTS..... 9⁰⁰
READING.....
MATH.....
ART.....
LUNCH......
SOCIAL STUDIES...
~~SCIENCE~~......

SCIENCE: AN ENDANGERED SPECIES

Figure 1.

CHAPTER 3

VALUING SCIENCE CONTENT: SCIENCE IS A BASIC WE ALL CAN DO

James A. Shymansky

and

D. Wayne Green

PROLOGUE

We know that elementary school teachers, school administrators, science supervisors, and parents are very busy and are not likely to have time to read every bit of every article written about the value of science. This paper is organized to save your valuable time. Major ideas are highlighted at the beginning of the various sections and developed in the text. We've also included some illustrations to emphasize key points in the paper. We suggest that you read the highlighted statements through first and look at the illustrations. If you're interested and want to find out more about one or more of the main ideas, double back and read the sections.

> SCIENCE IS NOT A COLLECTION OF FACTS NOR IS IT A COLLECTION OF LAWS AND THEORIES. RATHER, IT IS THE SEARCH FOR ORDER IN THE NATURAL WORLD IN WHICH WE LIVE. THIS ACTIVITY WHICH WE CALL "THE SEARCH" CAN BE PURSUED BY ANYONE WHO HAS THE CONFIDENCE AND THE DESIRE TO DO SO. IT CERTAINLY CAN BE PURSUED BY ELEMENTARY SCHOOL STUDENTS AND TEACHERS.

To say that science is the search for order in the natural world may be deceptive in its apparent simplicity. To appreciate what this statement really says, it is necessary to examine the meaning and implications of the words "search" and "order."

Let's begin with "order." Most students of science, when asked what is meant by order, will respond with some description of a logical, hierarchical system of definitions, laws, and theories because these are characteristic of much of modern science. But these are rather advanced and sophisticated forms of the order present in the natural world. Many elementary forms of order which are much closer to our own experience exist in abundance. For example, the skin color of fruit is closely related to the ripeness of the fruit, wet clothes produce a chilling effect on the body, and the appearance of a fried egg depends on the temperature of the frying pan. The elementary forms and the advanced forms have one characteristic in common: they are all "regularities" in the midst of what seems to be a rather chaotic and random operation of the natural world. These regularities are what we mean by order.

Clearly the regularities which are a part of our experience are easier to deal with than the more abstract forms which we call laws and theories. Indeed, we deal with these elementary forms all the time; we guide our lives with them. Every day we carry out countless actions because experience tells us that these actions lead to results we wish to achieve. So common-place are these regularities that we often are unaware of them in a conscious sense. But familiar as they are, they are still examples of the order we search for and they represent appropriate starting points for the study of science, particularly for students in the elementary grades. It is in this sense that we say you know more science than you think you do.

While these regularities represent the content of science, they are not science; for science is the search for order, not the order itself nor even the application of the order. In other words, science is not a collection of facts nor is it a collection of laws and theories. Then what do we mean by "search" and how do we carry it out?

It goes without saying that we do not find the regularities written out for us in nature (in textbooks, yes, but then that eliminates the search). So how do we find the regularities? Often we stumble onto them by accident. Sometimes we just happen to notice that two things are related; e.g., realizing that boiled potatoes take longer to cook in Denver than they do in Chicago regardless of the kind of potatoes or the pan used. Sometimes we find a regularity by voluntary, but random actions. For example, you may want to loosen the lid on a jar. You try shaking it, banging it on the table, putting it in the freezer for a while, immersing it in warm water and, then, you try running hot water over just the lid and the lid loosens. The next time you have tight lid you try the hot water treatment and again it works. Now, you have found what appears to be a regularity. (It really does work surprisingly often!)

If you stop there and simply use the technique to loosen lids, you are not doing science. But, if you begin to ask questions and then devise ways of answering them, you are doing science. Will cold water work as well as hot? Will the technique work with metal lids on metal cans? Why does the hot water loosen the lid? The questions are endless. But each one leads to an activity designed to answer it and every answer gives rise to several more questions. This is the case with every regularity. Posing questions and devising activities to answer them constitutes the search for order.

NIGHTMARES!

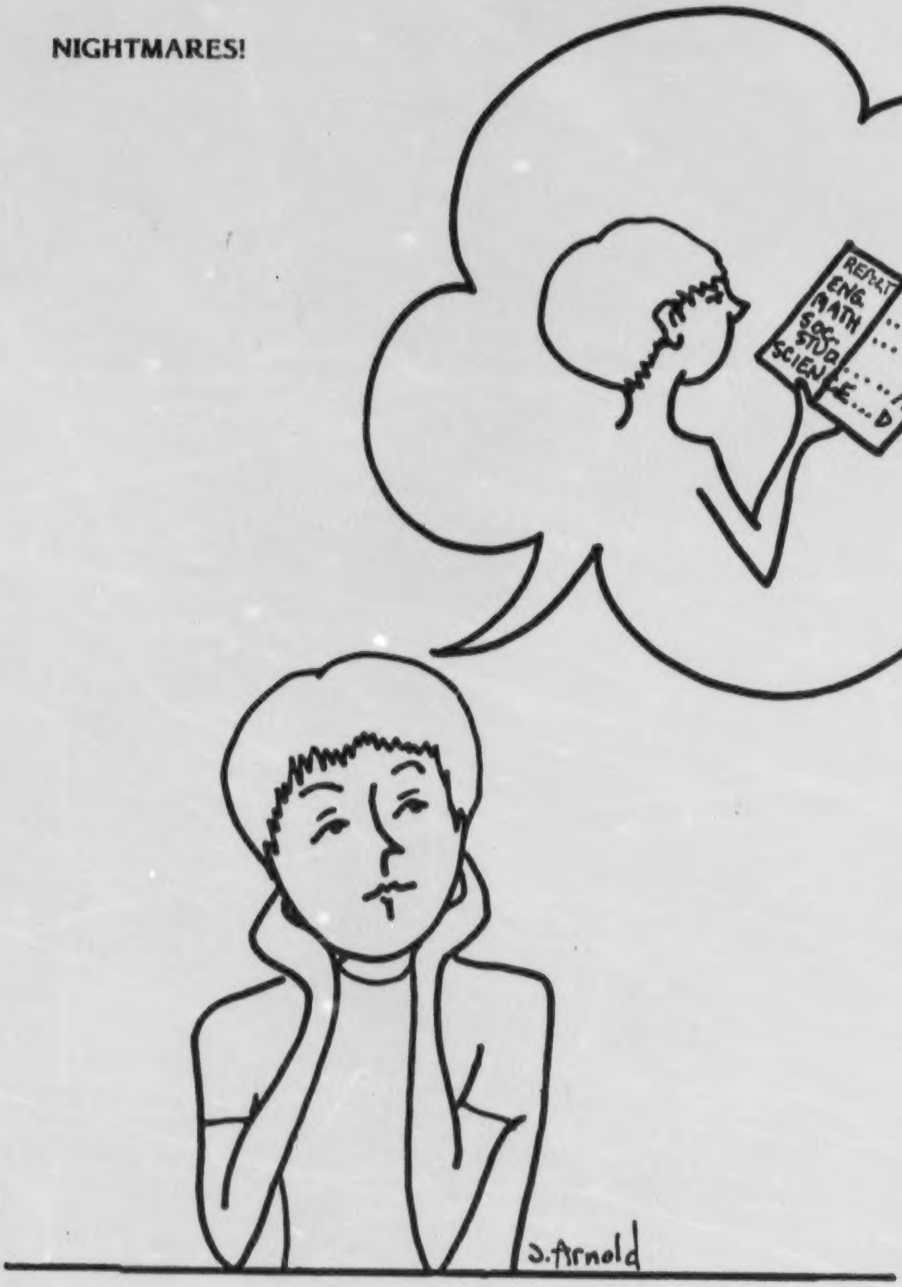

REPORT CARD
ENG. .....A
MATH .....B
SOC. STUD. .....A
SCIENCE...D
J. Arnold

Figure 2.

The search is more than anything else, a way of thinking. It is an inclination to ask questions and to seek answers. It is a willingness "to pursue where it leads."

This last statement is important. Rarely does the search lead where you expected it to; subsequent questions are prompted by the answers you have just found. As more information is accumulated, you try to make sense of it; i.e., you try to think of a regularity that, if it were true, would explain or account for the information or results you have found. This is what we mean by the logical thinking which is usually associated with science. But do not be frightened by this. Thinking this way is quite natural as long as you just concentrate on the answers they actually obtain and not worry about the answers someone has said you were supposed to get.

From the foregoing, it is easy to see that most of the regularities we find are ones we thought of and then set out to check. That is, each question really comes from an idea about what might be happening. This is what Einstein meant with his definition of science as ". . . the attempt to make the chaotic diversity of our sense of experience correspond to a logically uniform system of thought." (Einstein, 1940, p. 487).

Doing science isn't just for special people though. It's for anyone who wants to do some special things. Most of us are capable of doing science because we know more science than we think we know. Why then do so few elementary school teachers feel prepared to teach science (22 percent according to Weiss 1978)? The answer is simple: the other 78 percent believe they know little about science. They feel they lack adequate content background.

We are going to try to convince you that you know a lot more about science than you think you know. We believe you can teach children meaningful, exciting science without a degree in science or any minimum number of science credits, for that matter. The only obstacle in the way to your becoming a successful science teacher is you.

> IN SPITE OF THE PRECEDING COMMENTS, ELEMENTARY TEACHERS AVOID SCIENCE AND VIEW IT AS UNIMPORTANT. RAMPANT AMONG TEACHERS ARE MISCONCEPTIONS ABOUT WHAT SCIENCE IS, WHAT SCIENTISTS DO, AND WHAT IS NEEDED TO DO SCIENCE. THESE MISCONCEPTIONS, AND ACCOMPANYING NEGATIVE ATTITUDES ABOUT SCIENCE, ARE TRANSMITTED TO STUDENTS.

If the success of elementary school science is dependent upon a force of teachers in-serviced or pre-serviced with extensive formal science coursework, elementary school science is in deep trouble. Degree programs for elementary teachers simply do not require anything more than a methods course in science

HOME PROJECTS

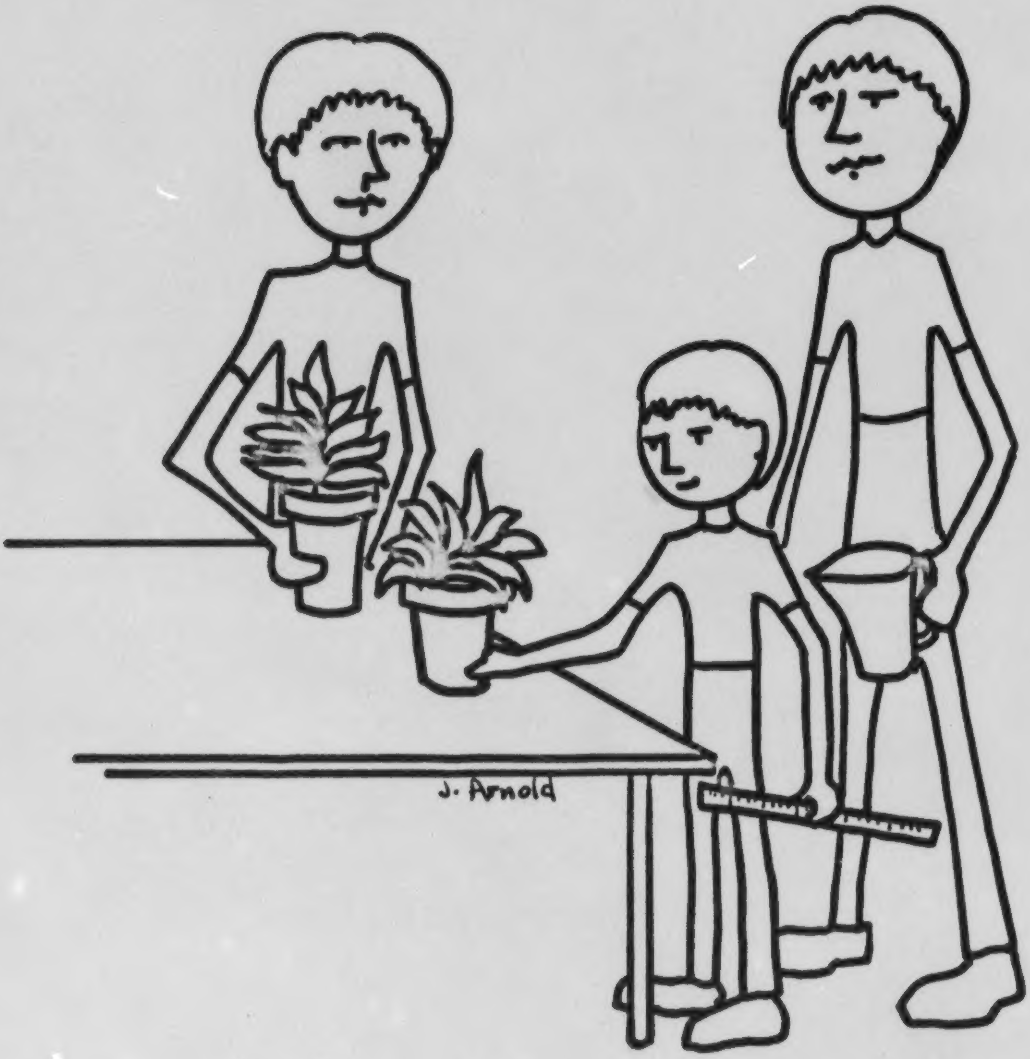


Figure 3.

teaching and one or two science courses. Elementary education majors normally do not pursue content minors. The most that can be hoped for in the way of course background is a 15-20 credit area of specialization in some content field. And this is usually not science. A breakdown of teaching specializations among practicing teachers and pre-service teachers reveals an abundance of reading and language arts approvals and very few science and mathematics approvals.

Why the aversion to science? There are three basic reasons. First, elementary school teachers, as a group, have not enjoyed overwhelming success in the science courses they've taken. It is difficult to be enthusiastic about teaching something that you yourself found difficult as a student. Success breeds success and confidence; failure breeds contempt. Most professionals can look back on any number of difficult experiences and laugh because they no longer have to deal with the subject. Elementary teachers aren't so fortunate. Science isn't necessarily behind them simply because they've completed a degree program. The prospect of teaching science for the next 35-40 years is just too much to swallow for many teachers. So they simply avoid it.

The second reason for the aversion to science relates to a practical concern: pre-service teachers perceive their own science instruction and their involvement in teaching science as having had little effect on their survival and success as interns. Moreover, they see their science experiences as having little or no impact on their future success in teaching (Cunningham and Blankenship, 1979). This feeling is pervasive in the profession. Once considered an essential in the curriculum, science has been pushed to the bottom of the priority list in most elementary school classrooms. It is only through the strong will of a handful of teachers and administrators at the elementary school level and the constant lobbying of science education support groups that science in the elementary school continues to exist at all as a distinct entity.

The third reason is more subtle; it involves stereotyping and misconceptions of roles. Nonscience college students, from whose ranks emerge elementary school teachers, have the perception that scientists are extremely methodical, rational beings who labor at important but mundane tasks. When evaluated against their own self-image, these students see the science roles as being very distant and incompatible with the role they see themselves assuming (Brush, 1979). Science is seen as valuable and worth pursuing, but by someone else.

Elementary school students also perceive a discrepancy between the science they know and do and what a scientist does. Some elementary school students were questioned about their view of themselves in science class and what scientists do (Shymansky, et al., 1974). They described the science that scientist do as exciting, creative and dynamic and their own as dull, mundane, and cut and dried--just the opposite of the college population reported by Brush. Somewhere along the line of school science experience, students evidently do a complete about-face on their perceptions of science and what scientists do. Apparently school science instruction is effectively distorting student perceptions of science and dampening student enthusiasm in the bargain.

> THE MISCONCEPTIONS ARISE FROM THE EMPHASIS PLACED ON THE SCIENCE CONTENT IN COURSES AT THE SECONDARY AND COLLEGE LEVEL, FROM POPULARIZED ARTICLES WRITTEN FOR THE GENERAL PUBLIC, AND IN THE INTERACTION WITH THE PRODUCTS OF SCIENCE AND TECHNOLOGY WHICH HAVE HAD SUCH A PROFOUND IMPACT ON OUR LIVES. VERY LITTLE ATTENTION IS DEVOTED TO THE "SEARCH" WHICH IS THE ESSENTIAL INGREDIENT OF SCIENCE.

We are living in an age of information overload. Even the most avid consumer is overwhelmed by the avalanche of new ideas and new technology that are generated almost daily. The time when the educated person could be expected to have a basic understanding of the natural sciences has long since past. Not only is new information in the sciences expanding in geometric proportions, entirely new fields of science are being spawned in the process (e.g., genetic engineering). This information explosion has clear implications for how teachers of science are prepared and how teachers teach science to children.

What constitutes a reasonable science background for an elementary school teacher? Traditionally the solution has been to place prospective teachers in a limited number of introductory level courses where basic principles of physics, chemistry, life science, geology, meteorology, and such are covered. These courses tend to focus slightly on the derivation of basic principles and the evolution of thinking in the field and heavily on the products of those processes. The result is a student who can recite small bits of information on cue but who has little concept of what science is or how such information comes about. Science for most students is viewed as a "rhetoric of conclusions" (Schwab, 1963).

When prospective teachers learn science as a collection of dead, unchanging facts, the probability is high that they will teach science to children in the same way. The problem is that teachers, being far less interested or knowledgeable than the science instructor from whom they learned their bits and pieces of science, are unable to transfer the informational part of the science accurately to their students. What the children receive is not only an incomplete picture of the science enterprise but a distorted recounting of the facts.

Teachers need not be dispensers of information. This is especially true of elementary school teachers. It makes a lot more sense to shift the emphasis in elementary school science

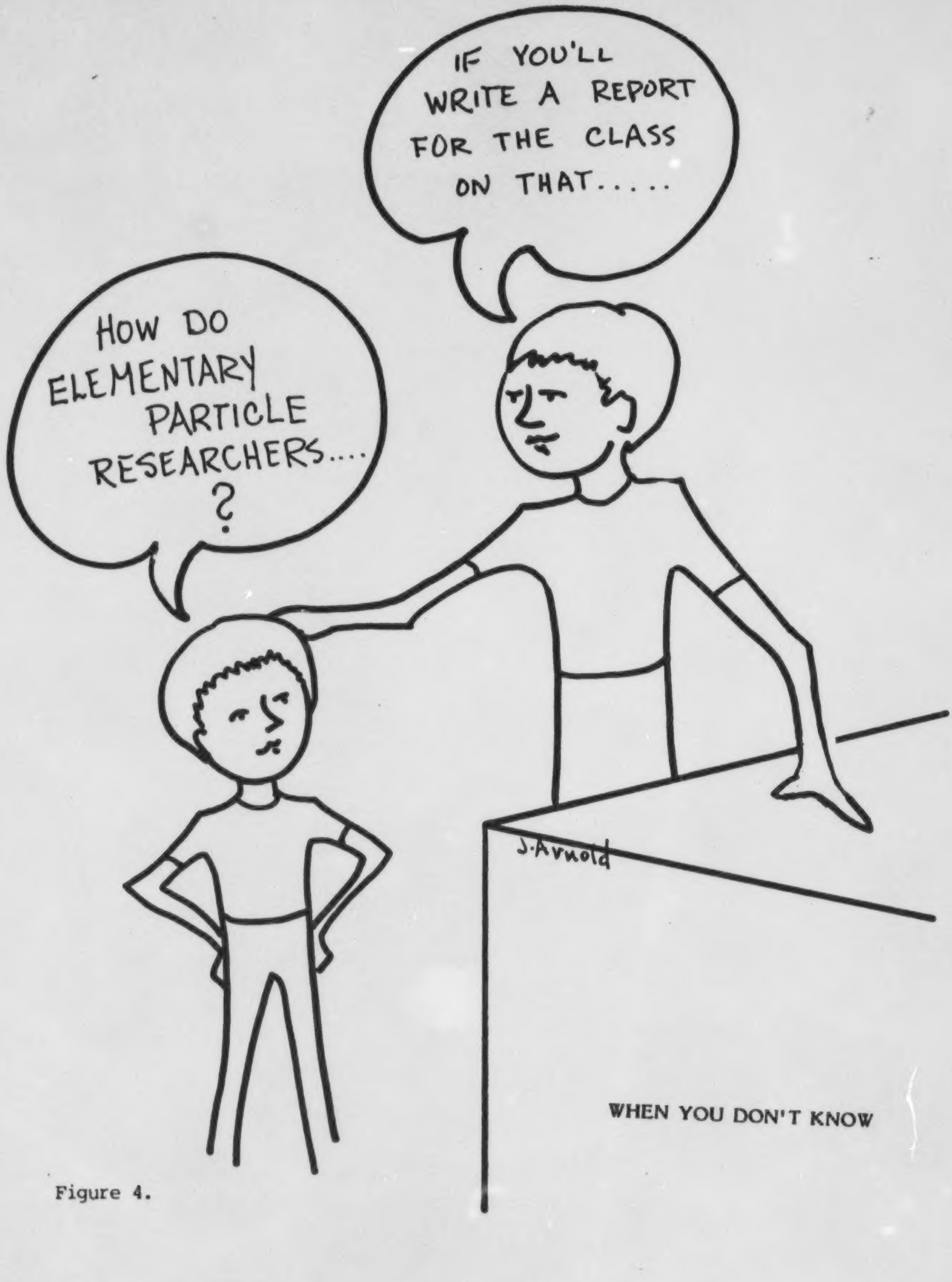

IF YOU'LL WRITE A REPORT FOR THE CLASS ON THAT.....
HOW DO ELEMENTARY PARTICLE RESEARCHERS....?
J.Arnold
WHEN YOU DON'T KNOW

Figure 4.

classrooms to the question of how we know what we think we know in science than to continue to convey an incomplete and inaccurate account of what is known. Such a move would lighten the burden of many teachers who now feel inadequate in their science background. It would also positively affect student perceptions of what science is.

This change in emphasis is consistent with the statements made by the Project Synthesis elementary school science focus group in their outline of "the desired state of science in the elementary school" (Pratt, 1981). In writing about the desired goals for academic preparation, the group stated that "there is no one set of basic topics for elementary science instruction . . . a variety of topics may be used to help develop the skills in generating, categorizing, quantifying, and interpreting information" (p. 76). Though these goals were proposed for adoption in the elementary school curriculum, they are equally valid for prospective teacher science programs.

> SHIFTING THE EMPHASIS FROM THE CONTENT OF SCIENCE TO "THE SEARCH" BRINGS THE STUDENT AND THE TEACHER FACE-TO-FACE WITH SITUATIONS WHERE ANSWERS ARE NOT KNOWN BEFOREHAND. BECOMING COMFORTABLE WITHOUT THE CRUTCH OF KNOWN RIGHT ANSWERS IS EASIER IF THE PHENOMENA UNDER INVESTIGATION ARE THE COMMON EXPERIENCES ALL OF US HAVE ENCOUNTERED. THINGS THAT ARE FAMILIAR AND RELEVANT ARE EASIER TO LEARN ABOUT WITH THE "PURSUE IT WHERE IT LEADS" APPROACH.

You are probably saying to yourself, "If there is no one set of basics in science, where do I start?" You start with familiar experiences and common everyday phenomena that are normally taken for granted. The example of loosening the jar lid under hot water is one example of a common experience that contains a lot of basic science. If that's too sciencey for you, start with a more observable phenomenon--for example, growth. What is growth? How much does something grow? What affects growth? These are very profound questions that can be pursued in a variety of contexts that will interest students.

With intermediate grade children (grades 3-5), the growth of a leaf on a tree at home or near school provides a ready-made investigation. A single leaf's growth can be monitored across several days to study changes in leaf size, color, mass, orientation, composition, and a variety of other characteristics, limited only by the student's creativity and curiosity. In studying the leaf many secondary and tertiary problems arise: How is size determined? How do you weigh a leaf that is still on the tree? How do you simply find the same leaf everyday? How do you measure leaf color? The seemingly easy science exercise of studying growth suddenly turns into a challenging investigation with something for everyone.

KEEP PARENTS INFORMED

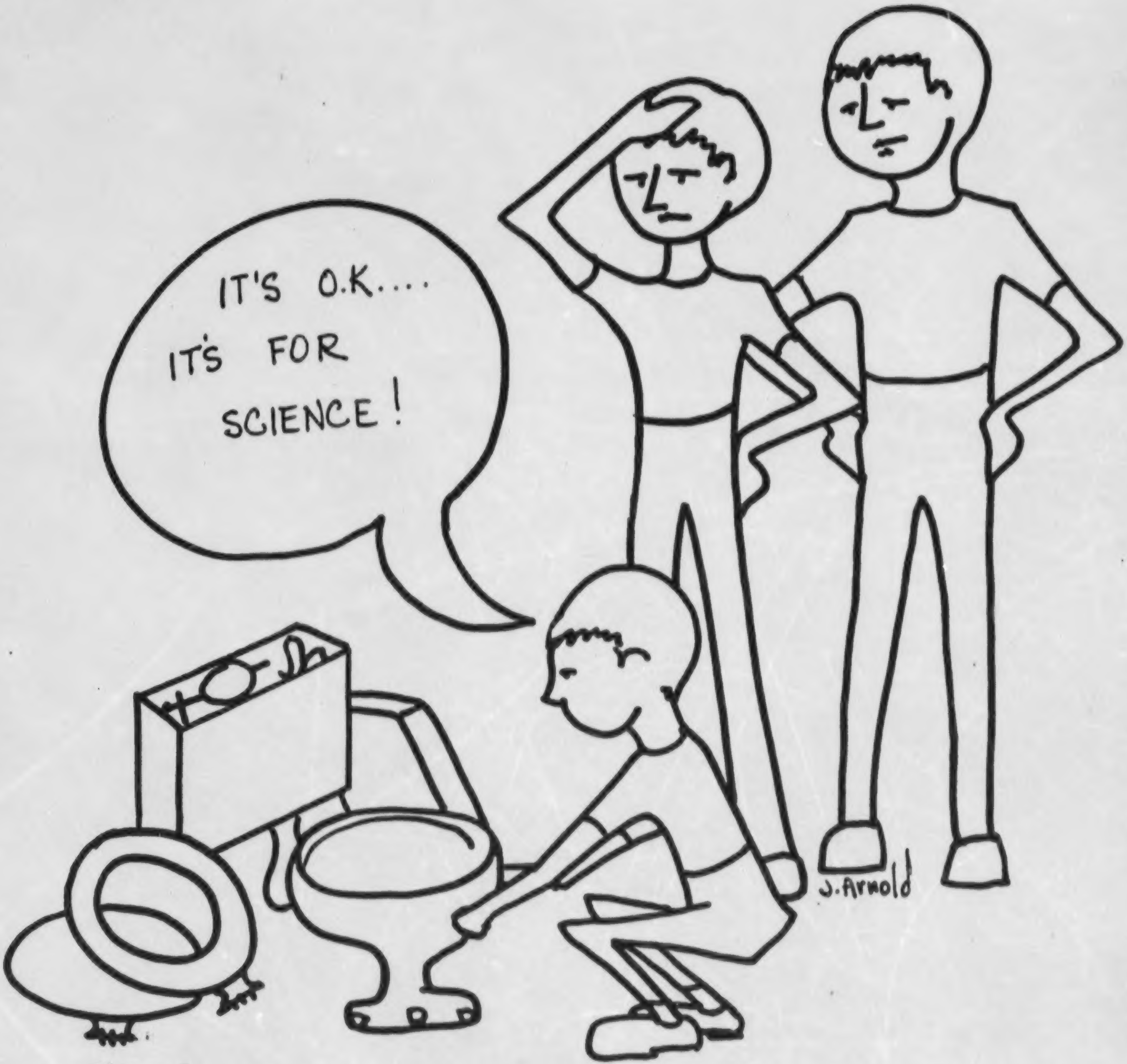

IT'S O.K....
IT'S FOR
SCIENCE!
J. Arnold

Figure 5.

A critical component of science is making observations (reliable observations), and recording data. The problem of monitoring leaf size has some interesting possibilities. Students can measure lengths from certain reference points--in centimeters, millimeters, inches, or home-made units on a paper or stick. They can also trace the leaf from day to day on paper and superimpose the successive tracings on one paper to obtain a record of growth. They might simply draw the leaf and incorporate size estimates in their drawings. Don't rule out descriptive narratives in a log format, especially for observations. The possibilities and science potential expand rapidly as the concept of growth is pursued. That's science.

From the student's point of view, the activities you select should be interesting and should produce some rather concrete results. From your point of view, on the other hand, the activities should contribute to the development of some skills, techniques, concepts, or attitudes which are important to, and characteristic of, science. This is the structure you must always keep in mind even though there is no way you will be able to talk about it with your students. They may be developing a particular attitude, but they will not be able to comprehend a discussion of the attitude.

What are some other things elementary school students can do in science? The first thing that comes to mind is classification. Your only problem is to collect (or have the students collect) enough different things. Leaves in the spring or the fall, flowers, rocks, fruits, nuts, paper, fasteners, and containers are some examples, but the list could be endless. The idea is to have collections which can be classified in many different ways. One way is not enough. You should keep asking the students to classify in some other way than they have already. This will help students sharpen observational skills and practice a "contrast and compare" strategy, both of which are essential in problem solving.

Classification creates a need for better ways to describe things. Better writing and word skills are a natural outgrowth of classification. A game can be devised in which one person writes a description of an object and another must then find it from among a number of other items in a collection. Classification is the basis for description. But descriptions must be carefully conceived. For example, saying, "The leaf has a long stem" has no significance unless there are leaves with shorter stems. Learning to observe and write with precision will enhance a student's ability to think with precision.

The "pursue where it leads" science has the added advantage of accommodating multiple levels of students within the regular classroom; that includes the slow learner and the talented or gifted student. The slow learner is not as likely to be threatened with science when the topics are familiar and varying levels of investigation and success are possible. The talented and gifted student can also be challenged within the same context. In fact, you might be surprised to find that some of your slow learners actually function better and show greater flashes of insight in the "pursue where it leads" science than your talented and gifted group. What often happens is that the so-called talented and gifted students get frustrated when a right answer doesn't quickly emerge, regardless of what the problem is. As Wasserman (1982) points out:

> They (talented and gifted students) [sic] are crippled by fears of making mistakes, and their anxieties manifest themselves in a variety of stress-related physical symptoms. Because school tasks are largely of the 'single, correct answer' type (e.g., "The sea is made of water"), these children have become gifted lesson-learners--excelling at the lower-order cognitive tasks found in traditional textbook and workbook exercises." (p. 621)

Both you and the students need to accept and feel comfortable with ambiguity and tentativeness. When you're not dealing with a closed set of right and wrong answers, explanations stand on their own merit. Neither you nor the student is correct by virtue of position. This is consistent with what science is all about and is probably one of the most important pieces of content to be learned.

The leaf growth activity is just one example of a science unit that can be developed from a common phenomenon. Moreover, the activity has many other dimensions to explore. It is not our purpose to present a complete unit plan on leaf growth. But hopefully our point is clear: you don't need a course in plant physiology or taxonomic botany to pursue a leaf growth science study in elementary school. You know plenty to get started. You need only muster the confidence to begin the activity.

> STUDENTS NEED MODELS IN SCIENCE. TEACHERS AND PARENTS NEED TO GET INVOLVED IN SCIENCE ACTIVITIES BY WORKING WITH THE STUDENTS AND DOING SCIENCE ON THEIR OWN. IN-SERVICE EFFORTS NEED TO EMPHASIZE TEACHER AND PARENT INVOLVE-INVOLVEMENT IN DOING SCIENCE.

We hope that our message has been clear to this point. Science is more a way of how to go about finding out things than it is collection of facts. It's not the accumulation of information that characterizes science, it's the thinking and activity that's used to generate the information that is the science. The very essence of good science is nothing more than good thinking. No amount of coursework in science can guarantee good science. Nor is a minimum amount of coursework prerequisite to teaching good elementary science. The desire and ability to

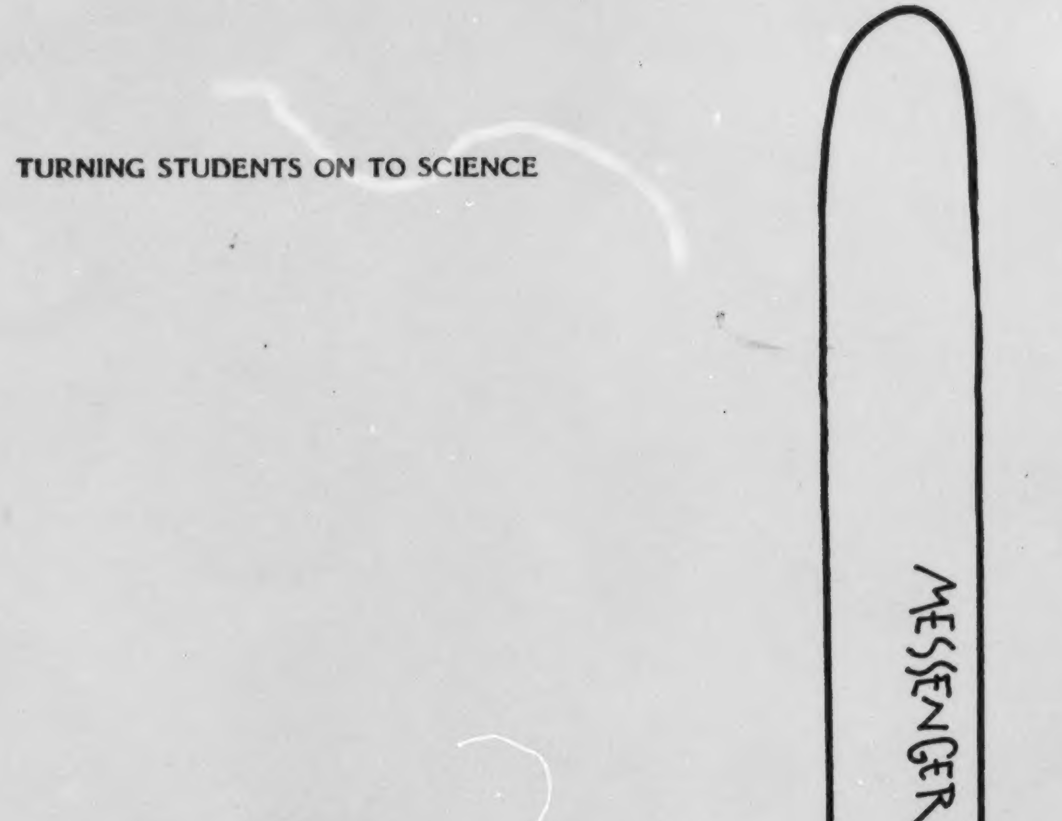

THINK WE SHOULD ASK FOR EXTRA CREDIT?
MESSENGER I
J. Arnold

Figure 6.

think about and make sense of the world are the only prerequisites to doing science.

What kind of in-service activity is needed to help elementary school teachers implement good science programs? To answer that question, let's start with some things that are not needed. Not needed is a new round of traditional science summer institutes of the National Science Foundaion type of the 1960s. The courses were not inherently bad, they just did not meet the needs of the classroom teacher. Cumulative research results on the impact of NSF-supported science curricula suggest that students enrolled in the new science programs benefited less from the new courses when their teachers participated in in-service courses (Kyle, 1982). Recall that these in-service institutes primarily consisted of coursework in chemistry, biology, physics, and a variety of other "hard" coursework. The courses may have been personally satisfying and educational for the teachers, but their ultimate impact on the classroom was negligible.

Also not needed is a new round of curriculum development. No set of materials or textbook is teacher-proof. The tools of a trade are no better than the person handling them. Those who would point an accusing finger at any set of science materials don't understand the dynamics of classroom teaching. If an amount of money equal to that which was invested in the development of materials in the 1960s had been invested in re-orienting the thinking of the teachers, the impact of the curriculum materials would have been much greater. The teacher is the key ingredient in the successful elementary science classroom operation.

This is not to denigrate all science enrichment courses for teachers. But in-service programs that stress only the content of science are not enough. Teachers need the experience of generating information themselves to develop a complete appreciation and understanding of science. We are not talking about the "I've got a secret" strategy where students (in this case teachers in an in-service course) work to "discover" an answer or explanation that the instructor already knows. We are talking about incorporating legitimate science investigation into courses where participants can try out first hand the procedures which characterize science. The most straightforward way to ensure this component is to require investigations of everyday phenomena as part of the course. Even the simplest investigation forces one to think in ways that no amount of lecturing or readings can do.

The investigation into common phenomena suggests a second type of in-service that is potentially more powerful than any number of enrichment courses. This in-service plan involves both teachers and parents. If teachers and parents get involved in science investigations along with the students, the experience is doubly valuable. As a co-investigator with students, teachers can familiarize themselves with new science topics and supplement their own activity with background reading and materials on the subject. As co-investigators both the teacher and parents serve as role models for the students. Students identify with their teachers and parents; what they do, the students do; how they learn, the students learn. The power of a teacher working on a science project with students is no less than when a teacher gets out and shoots baskets with the students on playground duty or sits down for a game of checkers; students tend to follow the teacher's lead.

Teacher involvement in science activities is not hard to imagine. But what about parents? How can they be involved? It is not as difficult as you might think. Start out by giving students an investigative homework assignment on a regular basis. This assignment should involve some measurement or observation and data collection concerning some aspect of the household operation; for example, monitoring the generation of garbage for the family, the diets of various family members, the temperature of the water from the tap, the volume and temperature of water in the toilet, the fish bowl, etc. The main point is to make the student's science activity visible to the parents and other family members. Soon the activities can graduate to direct parent/family involvement; for example, suggesting each family member monitor his own temperature, caloric intake, exercise habits, sleep, etc. Chances are high that the science activities will be discussed at home, thereby reinforcing the major concepts of the topic and the notion that doing science is really a normal thing. Before long, student/parent investigations on related topics will appear. You'll know that you've got your science program moving in the right direction when students start working on their science projects outside the classroom.

> TEACHERS OFTEN CITE BUDGETS, LACK OF PLANNING TIME AND FACILITIES, AND ADMINISTRATIVE AND PARENT PRESSURE AS MAJOR REASONS FOR NOT TEACHING GOOD SCIENCE. BUT NOTHING SUCCEEDS LIKE SUCCESS. OBSTACLES HAVE A WAY OF DISAPPEARING WHEN PROGRAMS SUCCEED. HERE ARE SOME COMMON REASONS FOR NOT DOING SCIENCE AND SOME RESPONSES TO THEM.

Fear of Not Knowing

Every teacher can recall being told sometime early in their teaching internship, "Don't be afraid to say, 'I don't know' when you are stuck on a problem or question." Actually, as an elementary school teacher, it is rare that you find yourself in a situation where such a confession is needed, unless you are venturing into uncharted regions of the curriculum. Most material is cut and dried and that includes science as it is traditionally taught. The implementation of a "pursue where it leads" science program means there will probably be a lot more "I don't know's" or "I'm not sure's" than what normally occurs in the classroom. But there will also be some new ones that will make it all worthwhile: new ones such as, "Let's try to find that out," or "What can we do to check the answer?" Remember: science isn't a collection of answers, but a way of thinking. You don't need all the answers; you can't possibly have all the answers. Students will get a much better understanding of what science is when all the answers are not known.

Fear of Being Different

Whenever a teacher deviates from the traditional pattern, principals and parents are apt to express concern. Parents may ask, "What is my child supposed to be learning in science?" or "How will this affect achievement test scores?" Principals may show their concern through more frequent classroom visitations during science. These are legitimate parent concerns and extra principal scrutiny may be a reality. The question is how to deal with them. There are several things you should consider.

First, avoid sudden departures from your daily routine; introduce new science activities gradually into your program. Remember, explorations into everyday phenomena are not intended to replace your existing science programs, but rather to supplement them. Moreover, a gradual shift into the exploratory type activity will help you build confidence in yourself and the approach--both keys to the successful science curriculum.

It is also important to keep the principal and parents informed whenever you shift gears in a program. When the principal knows what you're doing, he or she can respond intelligently to questions that may arise. Similarly, you can avoid problems by keeping parents informed. For example, before you make the assignment for students to make any measurements or observations at home, call or write the parents informing them of what you are trying to do and what support you hope to receive from them. That way parents aren't surprised or upset when they find their son or daughter with the lid off the toilet tank measuring the volume of water or weighing food portions that each family member consumes.

Fear of Losing Control

You are probably thinking to yourself at this point, "O.K., all this sounds good, but will I be able to maintain some semblance of classroom order when my students are following a loosely structured science activity?" This is a valid and practical question. But let us dispel one misconception about "pursue where it leads" science: Unstructured does not mean undisciplined or out of control. Students no doubt will be noisier when they are doing some science activities. Mere movement about the classroom by several students produces extra noise. But ground rules on loud talking, horse-play, destroying materials and interfering with others need to be established and enforced. This is not to suggest that you adopt unrealistic rules of conduct that will conflict with the goals of the activities. We are suggesting that you consider new ground rules to cover the special activities and consider involving your students in drafting the new rules.

Another way to deal with the control problem is to work on some of the constraints posed by the classroom environment. One solution is to move outside the classroom to do science whenever possible. This sounds facetious but there is merit to it. The broader the environment, the more relevant the science will be. The classroom is limited to what can be brought into it. The playground, the gymnasium, the hallway, the boiler room and school cafeteria are all places where science can be done.

Fear of Planning

You're probably thinking, "There just aren't enough hours in the day to prepare for this kind of science--I can barely afford the time it takes to prepare textbook lessons." The fact is that you will spend more time initially. But that prep time will even out and the rewards will be worth it. When elementary students are involved in science, their performance in related skills such as reading, writing, and computation improve (Kyle, 1982). The more related skills you can integrate in the science activities, the less pressure there will be to drop science or stop science; science will reinforce these areas as well. Also, once the students are accustomed to investigating on their own, more of the science can be done outside of class as small projects with students writing reports and giving presentations. Over time, your preparation time may even drop below that which you've spent on planning a textbook lesson.

SUMMARY

Science has fallen on hard times in the elementary school in the past ten years; teachers avoid it and administrators and school boards won't pay for it. Textbooks have replaced activity-based science programs in all but a few districts and isolated schools around the country. Once seen as a vital part of the curriculum, science is now being questioned for its usefulness and relevance. You, the classroom teacher, are the key to success in any program area and science is no exception. The difficulty with science is its perceived level of difficulty.

Science is not viewed as an everyday, routine sort of activity like reading, writing, and arithmetic. Without formal training in science, most teachers feel uncomfortable with it and incompetent to do it.

But science is an everyday sort of activity if we choose to approach everyday experiences with curiosity and systematic thought. Special facilities and special coursework are not needed to do science. Students can be encouraged to observe things carefully, record their observations, sort out the data, and think through explanations and reasons--in short, do science both inside the classroom and out. It is important that students perceive the content of science as a product of their own actions and their effort to make sense of the environment. Equally important is that students feel comfortable with making that effort and confident that they, too, can figure out explanations for things they encounter in their everyday living. We all know a lot more about science and do a lot more with science than we realize. It is only a matter of changing perspectives; science is not what we know but how we know. This is content every school child should learn.

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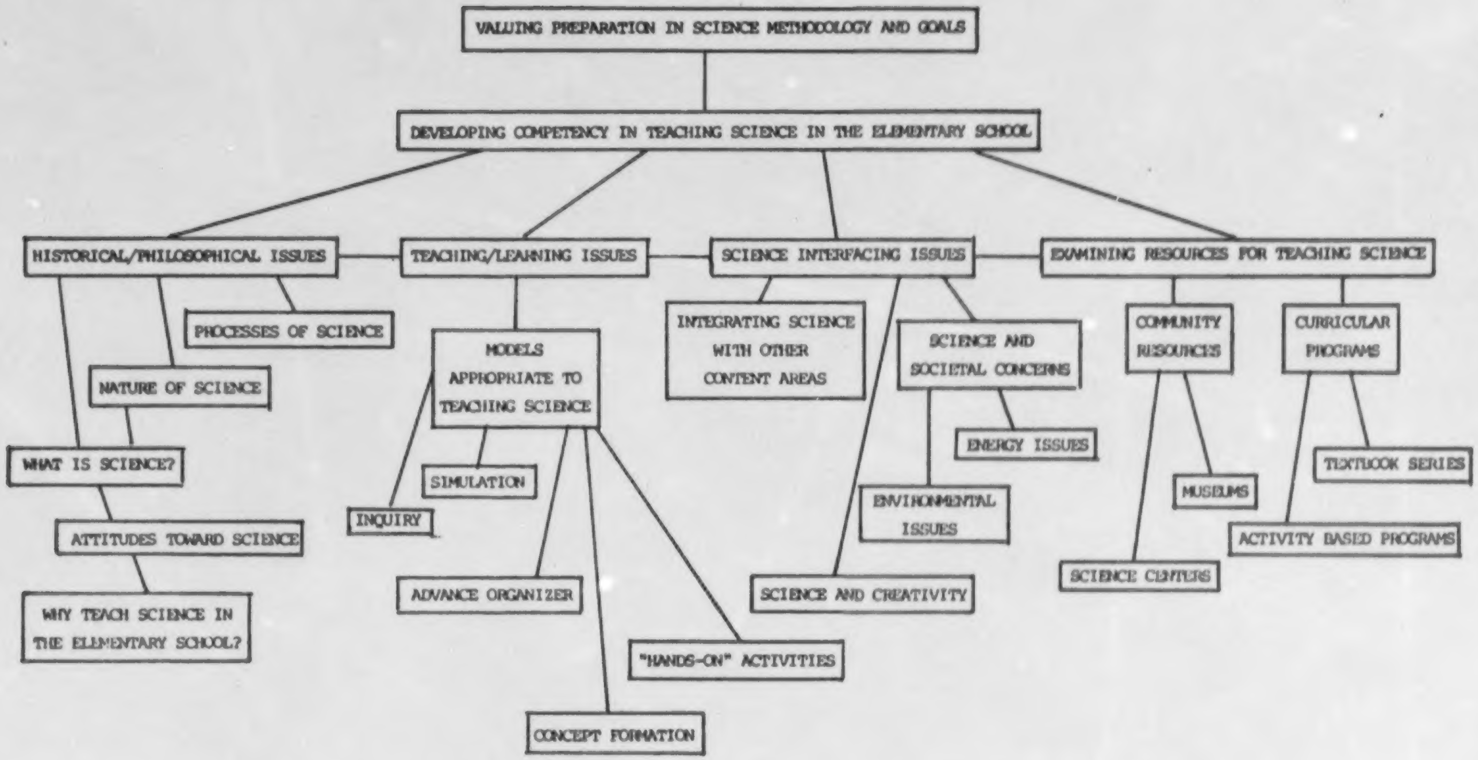
VALUING PREPARATION IN SCIENCE METHODOLOGY AND GOALS
DEVELOPING COMPETENCY IN TEACHING SCIENCE IN THE ELEMENTARY SCHOOL
HISTORICAL/PHILOSOPHICAL ISSUES
TEACHING/LEARNING ISSUES
SCIENCE INTERFACING ISSUES
EXAMINING RESOURCES FOR TEACHING SCIENCE
PROCESSES OF SCIENCE
NATURE OF SCIENCE
WHAT IS SCIENCE?
ATTITUDES TOWARD SCIENCE
WHY TEACH SCIENCE IN THE ELEMENTARY SCHOOL?
MODELS APPROPRIATE TO TEACHING SCIENCE
SIMULATION
INQUIRY
ADVANCE ORGANIZER
"HANDS-ON" ACTIVITIES
CONCEPT FORMATION
INTEGRATING SCIENCE WITH OTHER CONTENT AREAS
SCIENCE AND SOCIETAL CONCERNS
ENERGY ISSUES
ENVIRONMENTAL ISSUES
SCIENCE AND CREATIVITY
COMMUNITY RESOURCES
MUSEUMS
SCIENCE CENTERS
CURRICULAR PROGRAMS
TEXTBOOK SERIES
ACTIVITY BASED PROGRAMS

CONCEPT MAP: CHAPTER 4

CHAPTER 4

VALUING PREPARATION IN SCIENCE METHODOLOGY AND GOALS

Glenn McGlathery

INTRODUCTION

When an author attempts to encapsulate the trends current in an area such as elementary science education, the pervasive question centers around whether or not this can actually be done. It's easy enough to review the current literature, factor in one's own biases, and give the best estimate of direction. The chance always is there that the author is preparing one of those priceless vignettes, a "snapshot" of the field as it was in one fleeting moment and will never be again. Grasping at straws as they are tossed about by the fickle winds of change is a risky business at best and anachronistic foolishness at worst. If some teacher of the future reads this chapter and finds it "quaint," please know that it was written when "change" and "new direction" were key words in elementary science education, although it is difficult to know the extent or nature of the "change" or the heading of the "new direction." The consensus is that science education is in crisis (Yager, 1981) although some (Sheldon and Yager, 1978) consider the crisis to be an historical turning point, the possibility exists for going beyond the crisis to a period of restoration instead of further deterioration.

The decade of the sixties started as if it would usher in the golden age of science education. The formation of the National Science Foundation in the mid 50s and the national resolve to improve our science and science education heralded a new direction in the pre-college study of science. High school curriculum projects such as Physical Sciences Study Curriculum (PSSC), Chem Study (CHEMS), Chemical Bond Approach (CBA), and Biological Science Curriculum Study (BSCS) set a new precedence in curriculum development. Committees of scientists, psychologists, classroom teachers and science educators worked in collaboration to produce materials that were widely field tested and refined before being released for general use.

Development in elementary science followed in the 60s with the same general philosophy: presenting science as a "doing" rather than a "learning and reading about" activity. Curriculum institutes were sponsored by the National Science Foundation for elementary and secondary teachers so that they could improve their science information base, learn the philosophies of the "new" science, and prepare to introduce the material to their students. It seemed that the plan would work pretty well, particularly at the secondary level where institutes were available for teachers and facilities in local schools could be improved with apparatus and supply purchases underwritten by the Federal Government through National Defense Education Act (NDEA) funds.

Initiation of new directions at the elementary level were faltering and short-lived. Three problems cropped up almost immediately. First, there are many elementary teachers. While science teachers at the secondary level could fairly easily be indentified and trained because of their relatively small number, elementary teachers, all of whom presumably taught at least *some* science, were too numerous to train in the new science curricula. While a small part of the elementary teacher population was trained, a much larger portion remained untouched by the cataclysmic changes envisioned for elementary science education. Finances and logistics dictated that only a small part of the elementary teacher population (probably less than eight per cent) would be reached with the "new" science. A second problem that arose in the introduction of "new" science in the elementary school was the nature of science as a discipline and the lack of enthusiasm most elementary teachers had for the subject. After all, science was only *one* of the subjects they taught during the busy day. What about reading, writing, arithmetic, spelling, language arts, social studies, and penmanship? Were these subjects to suffer so that science could be given more attention? Third, and perhaps most basic, many elementary teachers had an anxiety, almost a fear, about science. Feeling that they were ill-prepared in their undergraduate education, few were willing to expose their inadequacies in an institute or an in-service program. So, the *revolution* in elementary science came and went with perhaps ten per cent of the elementary teacher population being affected in more than a superficial way. Perhaps this brief look at the recent past will serve as a context in which to look at the present and future.

GOALS IN ELEMENTARY SCIENCE

This chapter will look at the goals in elementary school science as formulated from Project Synthesis (Harms, 1981) and reported in *What Research Says to the Science Teacher* (Harms and Yager, 1981). These goals will be used to describe a preparation program in science methodology. The chapter by Pratt (1981) in *What Research Says to the Science Teacher*, synthesized numerous research studies and offered goals in elementary science built around four goal clusters: namely Personal Needs, Societal Needs, Academic Preparation and Career Education/Awareness.

Goal Cluster I: Personal Needs

Students will:

Be able to exhibit effective consumer behavior. This requires the skills to evaluate the quality of products, the accuracy of advertising and the personal needs for the product.

Use effective personal health practices.

Have knowledge of one's self, both personal and physical.

Possess a variety of skills and procedures to gather knowledge for personal use.

Be able to learn when presented with new ideas and data.

Use information and values to make national decisions and evaluate the personal consequences.

Recognize that their lives influence their environment and are influenced by it.

Recognize and accept the ways in which each individual is unique.

Be aware of the constant changes in themselves.

Goal Cluster II: Societal Issues

Students will:

Recognize that the solution to one problem can create new problems.

Use information and values to make decisions and evaluate the consequences for others in their community.

Recognize that some data can be interpreted differently by different people depending on their values and experience.

Recognize the ways science and technology have changed their lives in the past by changing the coping skills available to them.

Possess a sense of custodianship (collective responsibility for the environment over a period of time).

Recognize that science will not provide "magic" solutions or easy answers; instead, the use of hard work and the processes of science are required to "resolve" rather than "solve" many problems.

Goal Cluster III: Academic Preparation

Students will:

Develop an understanding of information and concepts from a wide variety of topics selected from life, earth, and physical sciences. There is no one set of basic topics for elementary science instruction.

> This variety of topics may be used to help develop the skills in generating, categorizing, quantifying, and interpreting information from an environment.
>
> This variety of topics may be used for the sole reason that it is interesting to students at a particular age.

Goal Cluster IV: Career Education/Awareness

Students will:

Recognize that scientists and technicians are people with personal and human characteristics. (Teachers should use biographical sketches, personal knowledge, etc.)

Observe both sexes, minorities, and handicapped represented in the written materials to encourage equal access to science-related careers.

(Pratt, 1981, pp. 75,76)

Further, Pratt concludes that the program designed to meet these student goals should have the following characteristics:

Program Characteristics

Program characteristics which are viewed as desirable to produce student outcomes outlined earlier include:

> Genuine alternatives should exist so that real decisions can be made, real problems solved, and the consequences known or experienced.
>
> The problems presented to students should be definable, possible to accomplish, and should grow out of first-hand experience.
>
> Students should be actively involved in gathering data.
>
> Information that is presented should be clearly articulated through alternative modes; i.e., books, films, "hands-on" experience, etc.
>
> Information transmitted should be as appropriate as possible for the age level of the student and reflect how it was developed.
>
> Science programs should be interdisciplinary in nature (involving areas other than science).
>
> (Pratt 1981, pp. 76,77)

Given this set of goals and program characteristics, preparation in elementary science methodology should have at least these following components:

Historical/Philosophical Issues
Teaching/Learning Issue
Science Interfacing Issues
Resources for Teaching Science

PREPARATION IN ELEMENTARY SCIENCE METHODOLOGY

Historical/Philosophical Issues

Children and adults alike often misunderstand what science is. It's easy to oversimplify what science is and "explain" science so that it becomes an almost magical enterprise. Science "facts" are hard to come by, and the conclusions of most of science must be held as tentative, simply the best interpretation of our current data base. As an example that conclusions are tentative, consider the following. A widely taught "law" in science states that matter can be neither created nor destroyed. The law was known as "Conservation of Matter" and was generally believed to be incontrovertible. Einstein postulated in the early 1900s that small amounts of matter could be converted to large amounts of energy. Now, one can argue semantics of this particular case, but the law of conservation of matter seems incongruent with the notion of matter and energy being convertible. After the actual test of this theory of convertibility in the atomic tests of the 1940s, textbooks began to modify the law of conservation of matter to read, "matter can be neither created nor destroyed using ordinary means." Some laws die hard. The lesson for consumers of science is to hold conclusions tentative. This is easily said but hard to practice, particularly for those anxious for closure.

If new evidence causes science to change, so does another factor, the nature of the scientist. Children and adults are likely to view the scientist as some recluse dressed in a laboratory coat, poring over extensive data while perfecting some secret formula. In reality, scientists are people with the same biases, prejudices, and other shortcomings as any other segment of the human population. The biases of scientists often distort their science. Consider the work of Gregor Mendel. Mendel, an Austrian monk, toiled in the garden at his monastery. He became fascinated at varieties of peas and began to see a pattern in the offspring of peas of a certain type. A hybridization of short peas and tall peas, for example, produced offspring that were in a 3:1 ratio of tall-to-short peas. He carefully collected data and put it in a journal which he never published and probably never shared with anyone else. The journals were found 50 years after Mendel's death and were recognized as highly significant in the formulation of Mendel's Law, the basis of our modern idea of heredity. Mendel's painstaking work won him the title of "father of heredity." All well and good.

A statistician named Fisher in the early 20th century developed techniques for examining data that were random-based to determine if data were "fudged." Guess what? Mendel's data, when subjected to these analyses, proved to be too nearly perfect. In short, Mendel either altered his data or was very selective in his data. Recognizing a pattern in heredity, he simply made his data a little more dramatic, more nearly perfect. This foible of human nature does not make Mendel's Law less important, but it does make us more aware of our guillibility in accepting data and conclusions without a thorough examination of the methods of the investigator and an over-riding thought that maybe we are being fooled. Haven't we all behaved as Mendel? Has not one of us ever taken a laboratory experiment with a highly accepted "answer" and then "massaged" our data so that it fit the known answer? Harmless? Perhaps so, but it does give one reason to pause in the light of some great, new discovery and ask, "Who did this?" "What were his/her methods?" "What are his/her biases?" We need to carefully examine new information and decide if it warrants our acceptance, even on a tentative basis.

It is extremely important that elementary teachers experience science with the goal of learning something of the nature of science. It is important that they develop reasonable attitudes toward science which they, in turn, can show the children they teach.

It is equally important that elementary teachers come to grips with the question "Why teach science in the elementary school?" According to Pratt (1981) teachers identified barriers to the implementation of science programs in the elementary school. Some of these are:

> 1. Science is difficult to teach--requires more work and is less enjoyable.
> 2. Lack of time. Too much time is spent in preparing, collecting, organizing, setting up, taking down, and cleaning up.
> 3. Traditional text teaching. Studies indicate that most science is taught using textbooks.
> 4. Lack of dissemination of alternative science program. Most teachers (up to 92 percent) have never heard about new science curricula. About one-fourth use textbooks more than ten years old. Only 14 percent have attended an NSF institute.
> 5. Decline in supervisory leadership. Most school districts do not provide science supervision. (pp. 86-87)

In spite of such negative assertions, most teachers believe that science is important in the elementary school and that science assists in the intellectual development of children. These values are important if we are to have a scientifically literate society. Somehow teachers must give a reasoned reply to "Why teach science in the elementary school?"

Teaching/Learning Issues

Pratt (1981) presented desired characteristics for teachers responsible for elementary science instruction.

> The teacher should have "a demonstrated ability to use (and know the result of) appropriate teaching

> strategies, i.e., grouping of students, questioning strategies, inquiry techniques, evalution procedure, etc. (p. 77)

Joyce and Weil (1981) have defined several models of teaching in their book Models of Teaching and in three companion texts that treat eight specific models of teaching in three families of models; i.e, the personal family, the information processing family, and the social family. These texts provide an excellent vehicle for finding alternatives to the pervasive "lecture" model. A few of the models appropriate to science teaching will be discussed.

The Inquiry Model: Suchman is credited with the development of the inquiry model. Suchman recognized that very young children are indomitable question-askers. They never stop. Who? When? and most implicitly, Why? Suchman observed that the natural inquisitiveness of the young child seemed to diminish when he/she started to school and apparently disappeared by upper elementary grades (if question-asking were the criterion for judging inquisitiveness). In assessing this phenomenon, Suchman suggested that the climate for question-asking changed from the home environment, and children simply became accustomed to the school environment when the teacher, not the student, poses questions.

That the teacher is an inveterate question-asker is documented by McGlathery (1979) in his chapter, "Questioning Behavior of Teachers." Teachers are and have always been professional question-askers, asking on the average of over 300 questions per day, many rhetorical, most closed or convergent.

Suchman devised a strategy by which children were presented with some puzzling phenomenon known as a "discrepant event." The task of the students was to solve the mystery by posing questions which could be answered "yes" or "no" by the teacher. The procedure rekindles the inherent question-asking ability of the students and teaches them important strategies for asking productive questions.

Simulation: Joyce and Weil (1981) described the simulation model as an outgrowth of developments in cybernetics. The model reduces a situation to an activity in simulation so that students in a real way have some influence over the outcome. Such science/ethics questions concerning world population, world hunger, and environmental impacts lend themselves to a simulation model. Many excellent simulation games are available on the market. Ideally, the teacher can devise his/her own simulation game to tailor content or concept to be presented.

Advance Organizer and Concept Formation: David Ausubel is credited with the development of the idea of advance organizer. The advance organizer is a generalization presented at a high level of abstraction that serves as a link to previous knowledge or a framework in which to place new information. The advance organizer works quite well in science if the framework of the discipline is clearly presented. Opponents of this model for teaching science consider this approach to be didactic and only supportive of the lecture method. In defense of this model, the teacher can insure by his/her planning that the learner can be an active participant in the process.

Since the concepts of science (including content and process) are to be learned , a concept formation model can be utilized. Briefly, a concept formation model is used first by those planning the concept to be taught. The teacher provides the student with several positive exemplars (examples) of the concept and several negative exemplars (non-examples) of the concept so that the student can begin to distinguish the attributes of the concept being taught. The model, based on work by Bruner, Taba, and others leads the learner to identify essential attributes of a concept and thereby grasp the concept being taught. An elementary example of this model can be found in the game, Queen Anne. The teacher may start the game by saying that he/she will name some things that Queen Anne likes and some things that Queen Anne does not like. The object is for the student to discover what Queen Anne likes. For example,

> "Queen Anne likes apples but not oranges." (note: a positive and negative exempler has been given.)
>
> "Queen Anne likes books but not magazines," (note: students can ask, "Does Queen Anne like cookies?") Teacher will reply, "Queen Anne likes cookies but not candy."

The game continues as more and more children discover that Queen Anne likes things with double letters. Such as boots, letters, kittens (but not cats), etc.

The teacher of elementary science must learn alternatives to the lecture method if science is to be made interesting and is to be taught in an efficient manner.

In addition to learning multiple teaching strategies, the teacher of elementary science should, as Pratt (1981, p. 77) states, achieve "An understanding of the developing nature of the elementary student's mental, moral and physical capacities and the role that elementary science can play in enhancing their development."

Science Interfacing Issues

The single most glaring omission of the new science curricula or, for that matter, of the most widely used textbooks is the failure to interrelate science with societal concerns. It is as if science existed in a vacuum and had nothing to do with the human enterprise or the human condition. The new generation texts seem to be addressing these concerns. The elementary science teacher needs some experience in this area.

All learning is integrated. We have in the past created artificial barriers as we began to departmentalize information. Atoms belong in science. History belongs in social studies. Stories belong in language arts, figures belong in mathematics. It can't be that simple. Where does the topic "energy" belong? The topic is, of course, germane to all disciplines. In energy we deal with such concepts as heat, energy, laws of thermodynamics, etc. which seem to have a science flavor. But wait! Energy touches our lives, our society, and is relevant in social studies. What about the history of energy use, the economics of energy policy, the geography of energy resources, the ethics of energy utilization? It is important that we examine the mathematics of the energy crisis. We need to see consequences of exponential growth, of the depletion curve, and the cost per unit of energy. We are children of the universe, world citizens, inhabitants on the solitary planet with finite and diminishing resources. It is presumptuous to assume that so broad a topic "belongs" in science. Teachers must find ways to integrate and interrelate information to avoid oversimplifying immense problems such as energy, environment, world hunger, population, and health.

Pratt did an excellent comparison of the "desired" characteristics with content in frequently used texts. One can surmise that much improvement is needed in this area of interfacing science with societal concerns.

Congruence of Elementary Texts With Project Synthesis "Desired" Characteristics

Goal Cluster I: Personal Needs

Sub-Goal	A Frequently Used Texts	B NSF Texts	C New Generation Texts
1. Consumer Behavior	None	None	None
2. Personal Health Practices	Good to Fair	Low	High to Good
3. Personal Health Information	High to Good	Low	High to Good
4. Skills in Gathering knowledge	None	High	High to None
5. Ability to Change	None	High	Low to None
6. Decision-Making	None	Good	Low to None
7. Environmental Influence	None	Low	High to Good
8. Individual as Unique	None	Low	High to Good
9. Change in Themselves	None	Low	High to Good

Goal Cluster II: Societal Issues

Sub-Goal	Frequently Used Texts	NSF Texts	New Generation Texts
1. Solutions Can Create New Problems	None	Slight	None
2. Decision-Making and Community Consequences	None	Good in SCIS	Slight
3. Alternate Data Interpretaion	None	Good	Good in Some instances
4. Ways Science Changes Lifestyle	None	Very Slight	Some
5. Sense of Custodianship	None	Very Slight	Good in Some instances
6. Science is not Instant "Magic"	None	Very slight	Good in Some instances

Goal Cluster III: Academic Preparation

Sub-Goal	Frequently Used Texts	NSF Texts	New Generation Texts
1. Skill Development Emphasis	None	High	High to Low based on programs
2. Variety Based on Student Interest	None	High to Low based on programs	High to Low based on programs

Goal Cluster IV: Career Education/Awareness

Sub-Goal	Frequently Used Texts	NSF Texts	New Generation Texts
1. Human Side of Scientists	Some Biography	Little to None	Good in one Series Little to None in Others
2. Minority Access	Little	None*	Little

*These materials are extremely neutral with respect to sex and race since students do not have access to printed materials or photographs of students or adults (Pratt, 1981, pp. 79-81).

RESOURCES FOR TEACHING SCIENCE

Pratt (1981) reported that four most frequently used texts dominate curricula in elementary schools. These are: *Concepts in Science* (Brandwein), *Science: Understanding Your Environment* (Mallinson), *New Ludlow Science Program* (Smith), and *Today's Basic Science Series* (Navarra). Further, three of the curriculum programs funded by the National Science Foundation are currently being used in at least eight percent of the classrooms. These programs were *Elementary Science Study*, *Science Curriculum Improvement Study*, and *Science - A Process Approach*. Finally, four additional text series were also reviewed since it was felt that this "new generation" of text represents a third potential pool of influence on science classrooms. The four text series in the category were: *Ginn Science Program* (Atkin); *Elementary School Science* (Rockcastle); *Modular Activities Program in Science* (Berger, et al); *Elementary Science: Learning by Investigating* (ESLI).

(PRATT, 1981, p. 79)

An examination of these data charts indicates that no single program or category provides material equally well in all four goal clusters; but what should be noted is that by selecting materials from more than one series or category virtually all sub-goals of all goal clusters can be met. Materials *are* available which match the expectations of the desired state. Consequently, the above-mentioned programs or texts should be considered as prime resources in the teaching of elementary science. Community resources teachers of elementary science should survey the community to find additional resources for teaching. Persons in the community can act as resources to the elementary science program and can share expertise in their fields. The use of these community persons not only enhances the science program but provides much-needed career awareness to students. Also, the teacher should seek out the help of educators in museums and science centers in the community to serve as a resource in the science program. A visit to such a cultural center can enhance a science program and strengthen concepts developed in the classroom. The use of educational tours and materials developed by educators in the museum can serve to extend information and enable students to look at information in a different context. The use of community resources has at least two-fold advantage. First, the science program is enriched. Second, the teacher develops that vital tie with the community that makes for better understanding, cooperation, and support.

Facilities, Materials, Equipment

Material resources are needed to make an elementary science program come alive. The materials used in exemplary science programs represent both the "boon and bane" of the program. On the other hand, the acquisition of materials makes a barrier in the teaching of science in the elementary school. The teacher must come to grips with the problem and make the necessary commitment to see that proper equipment is provided for the implementation of the elementary science program.

CONCLUSION

If the goals suggested by Project Synthesis are to be achieved, teachers of elementary science must receive instruction in educating themselves to deal with the new realities in elementary science. Teachers must learn to value, and become prepared in, the content, methodology, and goals of exemplary programs of science instruction (PRATT, 1981). Teachers should be open to change, particularly if that change can serve to excite the natural curiosity of students and lead them toward scientific literacy.

There is a crisis in science education. We must look on it not as a problem but as an opportunity to build a solid foundation for the science of tomorrow.

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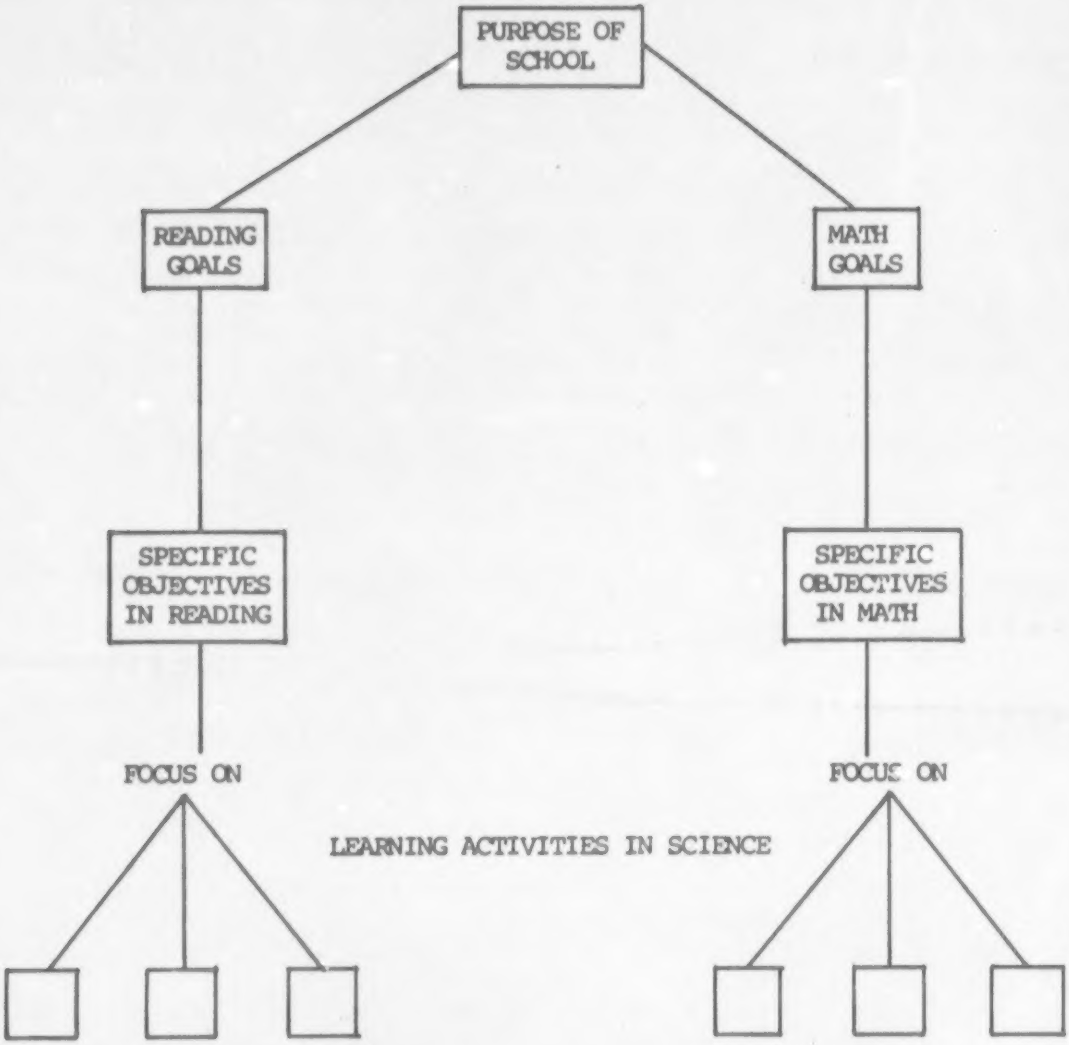
PURPOSE OF SCHOOL
READING GOALS
MATH GOALS
SPECIFIC OBJECTIVES IN READING
SPECIFIC OBJECTIVES IN MATH
FOCUS ON
FOCUS ON
LEARNING ACTIVITIES IN SCIENCE

CONCEPT MAP: CHAPTER 5

CHAPTER 5

VALUING THE INFUSION PROCESS

Ronald D. Simpson

and

David P. Butts

Infusion or confusion--that is an important issue. Consider the following dilemma. Mrs. Jackson is a first grade teacher at Kingswood Elementary School. Both her father and husband are scientists and her hobby is reading science fiction. While she has a deep personal as well as professional interest in science, her school system has just decided to administer competency tests in mathematics and reading. The first grade teachers at Kingswood feel pushed to cut back on art, social studies, and science in order to assure that the good image of the school continues. What do teachers do in this predicament? When they are going to be evaluated on the basis of student outcomes in language arts and arithmetic, can you blame them for emphasizing reading and mathematics in their curriculum? Yet, Mrs. Jackson, like some of her colleagues, intuitively realizes that first grade students enjoy science and that to deprive them of a good science experience at this important age is somewhat wrong. This dilemma is a common one throughout the country and is a subject for discussion in this chapter.

The general public in this country still considers reading, writing and arithmetic as basic to the elementary school curriculum. But how are schooling experiences relevant to students? Three suggested goals for schooling seem to reflect a common agreement. It should

1. enhance student self-concept through successful schooling experiences in reading, mathematics, and science;

2. improve student conceptual knowledge in those areas in reading, science, and mathematics in which his/her home environment has most likely limited his/her experiences; and

3. provide students with involvement in problems that are relevant to their out-of-school life.

In recent years teachers have become increasingly aware of the interconnections among reading, mathematics, and science. While reading and mathematics represent languages used by all literate citizens, science provides the knowledge, processes, and values toward which these languages are directed. Just as one must be able to read and calculate to "do" science, one must be able to utilize the tools of science in order to be a proficient reader or a good user of mathematics.

To illustrate these interconnections consider this hypothetical discussion at a meeting among three curriculum consultants representing reading, mathematics, and science.

Reading Consultant: It really bothers me when I see the school day of a first grader chopped up into so many small segments as the teacher sincerely pushes to "cover" all our curriculum demands.

Mathematics Consultant: But we must get in the basics.

Science Consultant: Hold on--what is basic? What do we think a first grader or a third grader should know or do?

Reading Consultant: In reading, one of the problems with first graders is that some are able to recognize letters and simple words while others cannot. Recognition of basic shapes which form the letters of our alphabet is fundamental to reading. Being able to describe things accurately is also a basic reading skill. Sometimes first graders need to observe something, then be asked to repeat what they saw. The same thing happens when someone reads something, then repeats what they learned.

Mathematics Consultant: Well in mathematics, they need to work with concepts in sets, whole numbers, and number theory as well as with initial ideas of measuring such things as money, temperature, time, and length.

Science Consultant: This conversation is really interesting to me. I believe that observing is the "stuff" from which science is made. Science experiences should be structured around this stuff, the tools of observing and the tools of communicating observations. To observe requires the child to see likenesses and differences. Color, texture, size, sounds, odors, animals, popcorn, time intervals, melting jello, and magnets provide a variety of sensations from which the child identifies similarities and differences. Tools of description include using space-time relations, measuring, and using numbers. These are initiated through activities emphasizing shapes, temperature, sets, leaves and nuts, and comparing lengths and units of measure.

If we were to cooperate, in first grade the curriculum would be aimed at making children more aware of their environment and being able to communicate their experiences. Observing and describing are processes in science.

Reading Consultant: Would there be a similar linkage at the second grade? For example, I believe that at this level, the act of reading is the act of communicating. When students can read something and later sequence or arrange logically the major events of a story, you know they are on their way to becoming good readers.

Mathematics Consultant: In mathematics we continue developing set concepts and numeration, with many teachers introducing the number law. As a communication tool, graphing is another topic that is introduced in mathematics.

Science Consultant: Had you thought about the fact that beyond the observation of similarities and differences of objects, you are soon confronted with change and the need to communicate that change? In science one second grade emphasis might be summarized in the word change. To describe change a child needs to make comparisons and to use a wide inventory of describing tools. Making comparisons is illustrated with topics such as animal shapes, metric measurement, similarities and differences of objects, animal foot prints, peanut variations, time intervals, forces, volume, and earth pull. Describing tools such as symmetry, angles, distance and direction, and graphs can be involved. The description of change is illustrated in such topics as weather, color change in cabbage, mold gardens, and colliding balls.

Mathematics Consultant: I had no idea that science emphasized these processes so much. It sounds like it would be hard to tell if a teacher was conducting a mathematics lesson or science lesson. In fact, you could say the same about reading. Why do we put so many labels on things that are in essence more alike than different.

Reading Consultant: You really deal with graphing in second grade? By third grade level, we are focusing on children gaining information from a variety of printed materials. Comprehension skills include communicating how we group larger events or objects into smaller categories. This is a fundamental reading skill. We also find that students in the third grade are ready to read and communicate results from graphs and tables. I wouldn't have believed it, but they can become quite skilled at this age.

Mathematics Consultant: At the third grade level, we usually extend the child's understanding of numeration systems and number theory. New topics such as the Roman numeral system, fractions, and geometry are included. But, I guess the most important aspect is involving students in practice using their mathematic skills in problem solving contexts.

Science Consultant: Science activities in grade three illustrate a natural shift from observing to communicating. Students communicate what they see, what they think they see, and what they expect to see. To communicate what they see requires that they both observe and relate what they see to other experiences. In other words, they learn to classify their observations. We see this done with topics such as aquariums, states of matter, animal motion, lines and surfaces, time, bacteria, graphs, dinosaurs, graduated cylinders, rates of change, phonographs, sundials, forces, plants, and estimations of linear distances. Communication of what they think they see (i.e., making inferences) is illustrated in such topics as inferring similarities and differences and describing mystery packages. What they expect to see--a prediction--is also illustrated through the use of graphs, opinion surveys, and extrapolation activities. Thus, in science there is an intended extension of observation to communicating observations, and going beyond to make inferences, and predictions.

Reading Consultant: But are there linkages between us for the third grade?

Science Consultant: From what you have both said, one of the commonalities we possess is that of teaching students how to use quantitative data depicted in graphic form in order to communicate relationships. It seems to me that mathematics helps us measure things and reading helps us interpret and communicate these ideas through a variety of arrangements or "displays." This is at the heart of good scientific methodology.

Reading Consultant: By the time students reach the fourth grade they should be able to take more sophisticated approaches to investigate studies as a direct result of increasing their competence in fundamental skills in comprehensive reading. Picking out key ideas and being able to describe them sequentially indicates comprehension. For example, I like to let students read something that is incomplete and then see how they "finish the story." I call that being a creative reader.

Mathematics Consultant: Creativeness is not limited to reading. In fourth grade we continue the child's development in understanding numbers through operations such as addition, subtraction, multiplication, and division. These may sound like dull drills but creativity is helping children know when to use a particular operation. Problem solving using decimals and fractions helps children link their mathematics with shopping at the mall.

Science Consultant: I believe that a key to grade four is couched in the word variable. Children observe properties of objects and identify how to change aspects of those objects to see what happens. Within this part, they are focused on

-describing variables,
-classifying variables,
-measuring and quantifying variables, and
-inferring variables.

The description of both the observed variables and the predicted or expected observations of these variables involves communication through graphs. As a tool, graphs require a combination of observation and classification of observations before their message can be communicated. From these data analyses emerge powerful tools we can use to extend our observations, inferences, and predictions. Describing variables can be practiced in such topics as bouncing balls, growth of plants and their parts, construction and interpretation of maps, coordinate description of location, two-dimensional drawing of three-dimensional figures, relative position in motion, graphing experiments with time as a variable, animal response to stimuli, and falling objects. Coding systems, color wheels, and punch cards illustrate the use of classifying variables. Measuring a variable necessarily includes determining the scale and its divisions. The topics of fractions, temperature and thermometers, meter sticks and decimals, evaporation, and large numbers illustrate the extension of the child's inventory of tools to use when he is identifying or describing variables. A fourth extension of his observation is the powerful opportunity of inference. Not only do inferences as statements of explanation help them to extend their observations, but they can extend this understanding of relationships among variables. Cartoons, tracks and traces, displacement of water, loss of water from plants, and evaporation are topics from which the child experiences the power of using inferred variables to interpret and describe his experiences. Grade four thus emphasizes the observation of variables including their description, classification, measurement, and inferred presence.

Reading Consultant: Have you all been copying our fourth grade reading objectives? I really see us saying that in fourth grade we have these common goals:

(1) to encourage creativity;

(2) to enhance ability in problem-solving;

(3) to continue to help students become more skilled in describing, classifying, measuring, and quantifying; and

(4) to assist students with their ability to make inferences. I did not view it this way until now, but inferring is the very essence of thinking.

But in fifth grade our concern shifts to developing greater depth in comprehension skills. In order to develop these higher-level reading skills students are taught to expand their use of synonyms. We play a game where students identify things from three or four characteristics or synonyms. Another strategy is to have students read short passages and then describe major relationships. This is an excellent way to improve reading.

Mathematics Consultant: Practice in problem solving situations is the key emphasis in fifth grade mathematics. Knowing your number combinations and practice in applying them to many situations helps children be at home in the "number world." Being at home in their world also means we must emphasize such topics as geometry, exponents, and graphing.

Science Consultant: In grade five we also believe it is time for greater depth in thinking about relationships. The child moves from inferring to beginning to formulate hypotheses which will not only explain what he has observed (about evaporation and condensation of moisture, for example) but which will specify how these hypotheses can be tested. We know that the child must develop his skills in using numbers, graphing data, and refining his application of these skills for the field of scientific inquiry through identifying fractions with decimals, using scientific notation, and learning to discriminate in selecting appropriate coordinates and scales for graphs, as well as through exposure to accuracy and error in measurement. His introduction to precision in the use of terms builds on his earlier developed skill in communicating using operational definitions. Such definitions must be statements about what must be observed and especially what must be done, if the object or process defined is to be clear, to himself as well as to others. His attention is also focused on the need to *control variables*, whether they are the environmental factors which cause mold to grow on bread, or the possible physical variations in the kinds of cylinders rolling down a plane, so that the experiments he ultimately designs and conducts will yield unambiguous data. The analysis or *interpretation of data* begins in the fifth grade with complex topics like animal behavior (a guinea pig learning in a maze) or chemical reactions.

A fifth grader must become aware of the necessity to imagine physical arrangements which will explain observed phenomena when limitations beyond his control prevent his handling the materials directly. Such imagination is needed in *formulating a model* of the section of the solar system in which he lives or to explain the observed phases of the moon.

Mathematics Consultant: Hold on now. Your science sounds like my mathematics. How can you . . .

Reading Consultant: Wait a minute! Remember what I said about comprehension skills? That's what you're both talking about: teaching students to not only interpret what is before them but to go beyond that and make something new. Whoever thought a reading specialist would be able to bring science and math together this way? You folks can thank me later for clarifying this issue for you.

I believe that in the sixth grade we not only try to expose the student to a wider variety of forms of literature, we also emphasize the idea that from basic relationships come concepts and principles which serve to guide our thinking. Concept formation is a higher order reading skill that accompanies abstract reasoning. We also know that being able to understand quantitative material in textbooks is an important reading skill. Is this an example of how science, mathematics, and reading merge into a single activity?

Mathematics Consultant: In mathematics we certainly emphasize the search for common rules in number prospectus and operations. Part of our search for common elements or relationships is illustrated in the wide variety of problem solving contexts in which the student must pick out what is to be solved, what information is needed, and what operation is appropriate to use.

Science Consultant: In science in the sixth grade, the emphasis on integration continues. Here there are larger subject matter units. With greater conceptual depth. For example, a topic can relate the physical nature of the earth, its magnetic field (which can be mapped) the effect of its rotational motion in the apparent daily path of the sun, and the determination of true north (the direction of the earth's axis) from such observation, mapping of physical surface features of the earth and three-dimensional mapping in general, and, finally, the introduction of map projections as models and their inherent distortions as one projects a curved surface onto a flat paper. In the quantitative area at sixth grade level, we think the child needs to learn the significance of ratios, and number and data relations, and appreciation of small numbers. Here is a good time to introduce them to probability theory by an activity on the analysis of chance. The use of these principles in considering biological phenomena, population studies and life cycles is at a simple level but an exciting introduction to social science as well as to statistical analysis in other fields.

We like to repeat ideas and concepts. For example, we can go back to the principle of the level which was studied in other physical systems. It can be analyzed in the functioning of arms and legs in biological systems. This kind of interplay between subject matter fields develops an understanding in later years of how new knowledge is synthesized and used. Biophysics is one illustration of this kind of development.

Reading Consultant: Do you agree that with the inclusion of more sophisticated topics in the sixth grade, we share these similar goals?

Mathematics Consultant: Yes.

Science Consultant: Certainly.

Reading Consultant: This discussion has been extremely helpful to me. Teaching students to properly use the language available to them is much more than just reciting words or describing events. It involves pulling things together into useful constructs and making this a part of our life. It means that our language becomes internalized. It means that what we read and what we say has meaning--that it makes sense to the user. I guess each of us thinks our subject is the most important or should be at the center of the curriculum. But when you put the focus on the student, you realize that in the real world activities don't come in bottles labeled mathematics, science, or reading. They occur as a result of integrating processes which are partly mathematics, science, and reading. You certainly can't teach one subject without the other. I wish there were ways we could share this notion with students, teachers, and parents. Let's go have a cup of coffee.

When objectives of the three subject areas are carefully studied, the natural integration emerges. Figure I illustrates this mutual strengthening of three basic subject areas: reading, mathematics, and science.

Topics can be generated that show this linkage. Sequencing topics and identifying shared objectives, however, are as academic as "paper" transactions. Translating this into classroom activities is the key challenge. Here is where the greatest impact arises from using science activities to generate the numbers on which the mathematics operations are practiced. Here is where reading skills are nurtured in ways meaningful to students. One teacher did it this way in a fourth grade topic of Counting Your Marbles.

Counting Your Marbles focuses on common characteristics or likenesses, the basis for describing collections of things to be thought of as sets. They may be collections of objects which have the same name (as books, cars) or the same color (blue, green), or the same class (as fruit, animals) or the same function (things to write with, travel in), or just because we want to think of them together. The idea of matched sets (sets having as many members as each other) provides the basis for number. From there we are "off and running" using a system of numeration for naming numbers and bringing meaning to expressions such as 2, 346, 85, and 1/2. Ways of developing this understanding are reflected in the use of numbers of situations where estimations are made of how many objects when the number is not readily observable. Thus, background for making decisions in selecting experiences to help our students attain the objectives of this topic focus on sets, set operations, and explorations with cubes, vegetables, and other things.

As children learn to describe sets of objects, to identify equal sets and equivalent sets and to name the number set, they use a system for naming greater and greater numbers based on ten symbols. They learn to experience quantity and to place value on what they have previously learned. These competencies lead to the studies in which children will need to answer the question "How many?". In addition to counting, however, they will learn how to use arbitrary amounts, handfuls, cupfuls, or bagfuls as ways to estimate the total number of objects. To make these estimations they will need to use concepts of volume or the measurement of stuff (e.g., a balance) to make estimates of how many objects are in a collection. It's rather clear that the smaller the object and the larger the container, the greater the total number will be. It may also be a part of the student's experience, that the larger the number, the greater the likelihood that individual estimates will vary. Precision is thus possible in group estimates based on pooled individual estimates.

Grade	Skills
First	Recognizing Shapes Recognizing Letters Recognizing Words Using Whole Numbers Understanding Sets Understanding Number Theory Measuring Communicating Observing Color Observing Texture Observing Size Observing Sounds Observing Odors Observing Organisms Observing Time Intervals Observing Physical Material Identifying Similarities Identifying Differences Describing Time-Space Relationships
Second	Communicating Events Sequencing Arranging Major Events Using Set Concepts Applying Numeration Graphing Observing Change Describing Change Communicating Change Comparing Contrasting Describing Symmetry and Angles Describing Distance Describing Direction Grouping Items into Categories
Third	Communicating Results Understanding Numeration Understanding Number Theory Using Fractions Applying Basic Geometry Classifying Observations Making Inferences Describing Materials Describing Events Making Predictions Using Graphs Illustrating Relationships
Fourth	Dealing with Multiple Characteristics Describing Sequences Comprehending What is Read Encouraging Creativity Number Operations Problem Solving Using Decimals and Fractions Describing More Complex Variables Classifying More Complex Variables Measuring and Quantifying Variables Inferring Variables Extending Observations Understanding Relationships

Figure 1. Summary of Potential Skills Shared by the Reading, Mathematics, and Science Curriculum

Figure 1 (continued)

Grade	Skills	
Fifth	Using Synonyms Identifying More Complex Characteristics Describing Relationships Using Number Combinations Apply Number Relationships Understanding Relationships Formulating Hypotheses Graphing Data	Using Scientific Notation Understanding Decimals and Fractions Using Scales Recognizing Error Appreciating Accuracy Recognizing Precision Controlling Variables Interpreting Data Formulating Models
Sixth	Forming Concepts Understanding Principles Abstract Reasoning Understanding Quantitative Readings Searching for Common Rules Searching for Common Relationships	Solving Complex Problems Integrating Problem-Solving Skills Understanding Ratios Exposure to Probability Theory Introduction to Statistical Concepts Internalizing Language

As students interact with objects, materials, and events and become more able to categorize and quantify these phenomena, they develop the ability to think more abstractly. This is basic to becoming a good reader. After engaging in this activity, whether it is called science or mathematics, the student is better equipped to understand what is read. As was stated earlier, not only does reading open doors for learning science and mathematics the reverse is true. Learning important concepts and processes in science and mathematics helps one to become a better reader. After completing Counting Your Marbles students can be assigned reading materials designed to expand their knowledge on this topic. Chances are they will be able to internalize more thoroughly what they have read.

Specific objectives for this infused topic were:

At the conclusion of this topic the child should be able to

1. demonstrate his/her concept of a collection of objects as a unit;
2. using verbal or tabular form, describe a set according to the characteristics shared by objects within the set;
3. identify and name equal sets, subsets of a given set, and equivalent sets;
4. name the number of a given set and the number of a set formed by the union of two given sets, using both the standard name and the name using the two numbers of the given sets;
5. demonstrate their basis for their estimates of the number of objects in a collection; and
6. describe variables that may influence estimations.

A second illustration is the topic Leaps and Bounds. Although initial meaning for multiplication and division is commonly obtained from equal additions and successive subtraction, other situations such as union of equal segments (jumps) on the number line or cross products provide experiences for a broader understanding of multiplication. Similarly, separating a number line segment into equal intervals (jumping backwards) and building arrays, knowing either the number of rows or the number of columns, enhances meaning for division.

Further meaning for multiplication and division can be enhanced by this correlated topic Leaps and Bounds. That is, multiplication can be regarded as rate problems. Relating another kind of situation which gives meaning to multiplication and division through the activities of rates of change and the use of multiplication and division in solving the problems provides immediate use and reinforcement of a mathematical concept and skill.

As with the first activity, concrete experiences set the stage for the more abstract behavior of reading. After students finish a topic such as Leaps and Bounds they are more capable of reading about numbers, sets, and time-space relations. Science and mathematics are not subjects open only to skilled readers. Science and mathematics use tools which improve reading and, of course, as reading improves a young person's mind becomes exposed to more options.

The eight objectives of this topic were:

At the conclusion of this exercise the child should be able to

1. demonstrate a procedure for finding products with one factor greater than 10;
2. identify objects according to their speed using such terms as "faster than" and "slower than";
3. state and apply a rule that the speed of an object is the distance moved per unit of time;
4. identify problems involving rate as a one-to-many matching between sets;
5. state a rule from a set of ordered number pairs and apply a rule to form ordered number pairs;
6. state and apply rules for association, commutative, and distributive properties of multiplication, identify element for multiplication, and inverse relationship between multiplication and division;
7. demonstrate how to find the mean (average) of two to nine numbers the sum of which is not more than 99; and
8. distinguish between speed, time taken to change position, and distance moved.

Our challenge is to produce an infused curriculum that illustrates cooperation among the child's daily learning experiences rather than competition. Seven steps or tasks help in accomplishing the pathway to cooperation.

1. Begin with clear communication of separate subject area goals.

2. Search for natural linkages or bridges between subject areas.

3. Select instructional materials that illustrate content that has potential for developing common skills.

4. Identify or develop specific learning activities in the topic areas.

5. Specify objectives for the learning activity as a way to provide sharper focus to their impact.

6. Find teachers who are willing to give a new topic a fair chance in their classes.

7. Keep tuned in to the classroom progress of students with the topic and modify as student and teacher feedback indicates.

SUMMARY

Is infusion a concept that confuses or one that should be valued? It is the thesis of this chapter that we are serious about making schools and schooling opportunities in which

-student self concepts are enhanced through successful learning experiences;

-student knowledge is developed in areas in which his out-of-school experiences may have been limited; and

-student learning is relevant to their out-of-school life.

We can do something more if the competition among subject areas is replaced with cooperation. Had cooperation in the space program not occurred, we might have witnessed the making of the world's largest slingshot instead of a modern spaceship. By building a curriculum in which subjects are infused and united, common educational goals relevant to all areas of instruction can be realized. Competition for energy and resources has been prevalent in the past. Cooperation appears to be a more promising model for the future.

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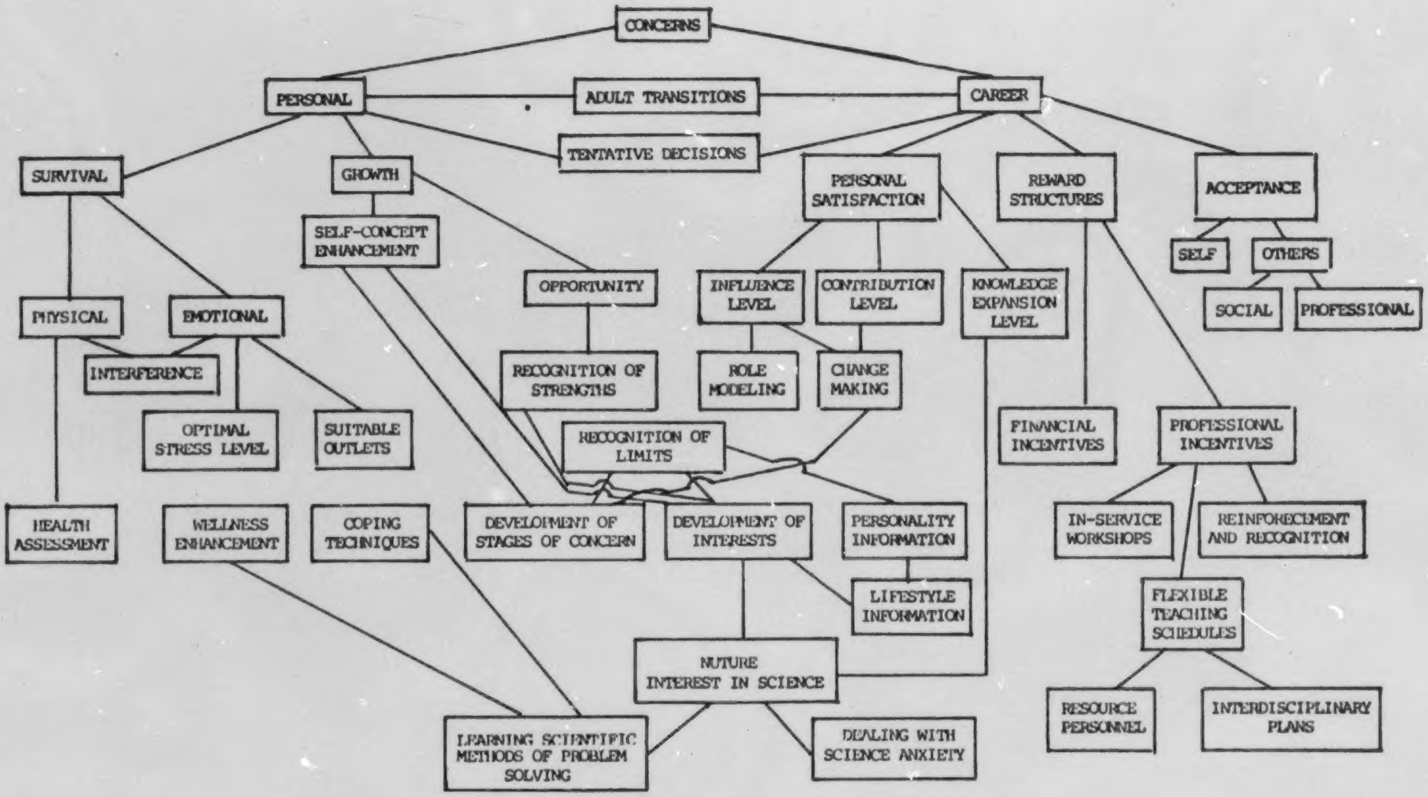
PART III

EXPLORING INTERFACES


CONCERNS
PERSONAL
ADULT TRANSITIONS
CAREER
TENTATIVE DECISIONS
SURVIVAL
GROWTH
PERSONAL SATISFACTION
REWARD STRUCTURES
ACCEPTANCE
SELF-CONCEPT ENHANCEMENT
SELF
OTHERS
OPPORTUNITY
INFLUENCE LEVEL
CONTRIBUTION LEVEL
KNOWLEDGE EXPANSION LEVEL
SOCIAL
PROFESSIONAL
PHYSICAL
EMOTIONAL
INTERFERENCE
RECOGNITION OF STRENGTHS
ROLE MODELING
CHANGE MAKING
OPTIMAL STRESS LEVEL
SUITABLE OUTLETS
RECOGNITION OF LIMITS
FINANCIAL INCENTIVES
PROFESSIONAL INCENTIVES
HEALTH ASSESSMENT
WELLNESS ENHANCEMENT
COPING TECHNIQUES
DEVELOPMENT OF STAGES OF CONCERN
DEVELOPMENT OF INTERESTS
PERSONALITY INFORMATION
IN-SERVICE WORKSHOPS
REINFORCEMENT AND RECOGNITION
LIFESTYLE INFORMATION
FLEXIBLE TEACHING SCHEDULES
NUTURE INTEREST IN SCIENCE
RESOURCE PERSONNEL
INTERDISCIPLINARY PLANS
LEARNING SCIENTIFIC METHODS OF PROBLEM SOLVING
DEALING WITH SCIENCE ANXIETY

CONCEPT MAP: CHAPTER 6

CHAPTER 6

SCIENCE TEACHING AND PERSONAL AND CAREER CONCERNS

Marianne B. Betkouski

CONCERNS: THE HUMAN ELEMENT

> Only one more hour left before that saving bell rings. I can tolerate anything for an hour (well . . . almost anything). Time to drag out those old science kits. I know my kids need science, but where are the resources to teach it? I don't have time to dig up earthworms! I wish I could sit down and really do science with these kids. It's not that I don't want to teach it. It's just that there are so many other basic skills to teach. Maybe if I had some help . . . someone to answer my questions--someone to help organize some activities. You know, as much as I love teaching, I'm getting tired of the hassles. Actually, I'm just plain tired. . . .

Is this scene too far-fetched, or is it happening daily in our schools, somewhere? According to Pratt (1981):

> The typical elementary science experience of most students is at best very limited. Most often science is taught at the end of the day, if there is time, by a teacher who has little interest, experience or training to teach science (Pratt, p. 73).

The picture emerging from three NSF studies and painted in the previous quote shows us a tired teacher who is trying to teach something for which she/he is ill-equipped. Our teacher is caught in an uncomfortable situation, operating at the survival mode, if that! If, however, a goal for elementary science is to ". . . excite students' curiosity, build their interest in their world and themselves, and provide them with opportunities to practice the methods of science" (Pratt, 1981, p. 75), it is easy for us to see the discrepancy between the real and the ideal.

If you are an elementary school teacher teaching science, I am interested in having you join me as I speculate on your personal and career concerns. If you are other than an elementary school science teacher, I invite you to join me in analyzing and appreciating the role played by teachers at probably the most important of all levels, the elementary school years. Before we begin our excursion, let us acknowledge some limitations. Personal and career concerns are highly individual matters. If you feel that you do not fit into the patterns discussed, do not judge either of us to be all right or all wrong. Hold on to your individuality and internalize those areas that are appropriate for you. We are attempting both to understand and to be understood. Let's do it together!

Although we are dealing with each of the categories of personal and career concerns as they apply to elementary school teachers teaching science, it would not be accurate to infer that these two areas are completely discrete. Just as doctors are beginning to take a holistic approach to the mind-body connection, so, too, should we be aware that our personal lives overlap into our careers and vice versa. The amount and nature of that overlap will change with age and experiences, but it will never be obliterated completely.

TRANSITIONS AND WELL-BEING

At times, such as during adult transition years or "passages," actual personal-career conflicts may arise. Elementary school teachers are, first and foremost, human beings! As humans they progress through various stages of adult development and become keenly aware that time to accomplish goals is limited in life and that happiness is not an automatic by-product of age. Newman (1981) summarizes teachers' reactions in the mid-career transition stage: "Having realized that the complete happiness they expected in their 20s has not materialized, they feel unrest or disillusionment. The challenge in this stage is to recognize the complexity of both the inner self and the outer world; in reality, neither is very simple or controllable" (p. 89).

Many times we wish for simplicity and certainly for control in our personal and professional lives. In any case, we would like to experience a sense of well-being. Gail Sheehy, in her book Pathfinders (1981), summarizes the characteristics of well-being which she has gleaned from surveys and interviews across diverse groups in this country:

1. My life has meaning and direction.
   (There is an involvement outside of self).

2. I have experienced one or more transitions in my adult years, and I have handled these transitions in an unusual, personal, or creative way. (Creative solutions to crises occur here; people of well-being do not become "mired in the past.")

3. I rarely feel cheated or disappointed by life. (The inevitable failures in life are viewed as useful learning experiences).

4. I have already attained several of the long-term goals that are important to me. (A comfortable life, family security, and a sense of accomplishment are deemed important).

5. I am pleased with my personal growth and development. (Highly prized characteristics are honesty, lovingness, and responsibility).

6. I am in love; my partner and I love mutually. (Exploitative relationships are rare in persons of well-being).

7. I have many friends. (These people are more loving and more lovable than those who do not experience a sense of well-being).

8. I am a cheerful person. (A positive outlook often attracts others who, in turn, help these people to remain cheerful).

9. I am not thin-skinned or sensitive to criticism. (The sense of self is highly regarded).

10. I have no major fears. (These people do not struggle needlessly; they can relax and be open to new feelings) (pp. 12-18).

If we were to apply these 10 characteristics of well-being to elementary school teachers teaching science, we could hypothesize that the more the teaching situation contributes to a sense of well-being, the better able teachers would be to feel free to become actively involved in teaching science. What could detract from an elementary school teacher's willingness to teach science? An obvious answer would be the feeling that one is not qualified -- one cannot "do science." Indeed, surveys will substantiate that fear. Results of a survey by J. G. Horn and R. K. James among elementary teachers (K-6) in Kansas show that

> . . . 45% of these teachers feel qualified to assist colleagues in reading, language arts, or English; 23% feel qualified in mathematics; but only 9% feel qualified in science. The same survey finds that the amount of time these teachers allot to science instruction reflects their subject area confidence. On the average, 342 minutes per week are devoted to reading, 212 minutes to mathematics, 133 minutes to social studies, and 88 minutes to science (Gerlovich, Downs, and Magrane, 1981, p. 22).

SCIENCE--A BASIC SKILL WITH TENTATIVE SOLUTIONS

How sad that our elementary school teachers have not been schooled in understanding what a basic skill science can actually be in their own and their students' lives. Science is not cold, hard, and to be feared. In a beautiful description of science, Jacob Bronowski (1973) emphasizes the tolerance, uncertainty, and humanity which must be present in the pursuit of science. Scientific answers are tentative, just as are so many of life's answers. Perhaps we can apply the methods of a very humane approach to science in identifying and plotting tentative solutions to the personal and career concerns of elementary school science teachers. If we do this, we are not taking too much of a risk. After all, that which is not written in stone is subject to change or modification!

We may divide the personal concerns of our teachers into two categories: survival and growth. Survival--making it from day to day--presumes that physical and emotional health are maintained. Talking with hundreds of teachers during and after several stress workshops I have conducted has given me a renewed appreciation of the high physical and emotional energy levels with which teachers must operate. But these energy levels are often forced and lead to conditions of fatigue and even "burn-out." Teachers, in the job of assuring the survival of youth, seem to be doing it at the expense of their own survival. Ironically, this condition seems to be associated with people in helping professions. The adage "physician, heal thyself," might be extended to the teaching profession where it would become, "teacher, teach thyself!"

SURVIVAL--IT CAN BE LEARNED

Actually, much of what affects our physical and emotional survival negatively is the result of learned destructive patterns of behavior. That which is learned can be unlearned. Teachers have an advantage here in that they are the keepers of many successful learning tasks and strategies. Colleges of education are recognizing the importance of teacher preparation in the area of "knowing thyself." Planners of in-service workshops for teachers already in the field are including more and more stress and coping workshops. Probably the most significant outcome of these endeavors is the teacher's own acceptance of humanness!

Educators must realize the reality and power of the affective domain. A pre-service course recently instituted at the University of North Florida in the area of interpersonal skills has the students assess their own communication patterns and possibly change what they themselves choose to change. In her book Peoplemaking, Virginia Satir (1972) describes the verbal and nonverbal components of five patterns. While she describes the drawbacks of being a placater, blamer, distractor, and computer, she urges us to lead the "juicy" life of the leveler who has attained congruence between the inner and the outer self. The quest to become real is much more possible for the forthright leveler!

Facing the self, making good decisions, and learning coping techniques are ingredients for teacher survival. These apply to both the physical and emotional realms. Health assessments and ways to enhance wellness are intimately bound to finding optimal stress levels and suitable outlets at the emotional level. A teacher who is tired and exists on a poor diet probably does not exhibit calmness and creativity in the classroom. Nor can she/he be the cheerful person who has attained well-being. It is important for each of us to take ultimate responsibility for our physical/emotional health. Coping techniques are individual and must be so-styled.

Coping with Interferences

Sometimes there seem to be insurmountable blocks to physical and emotional health. These "interferences" are real, and sustaining a positive attitude becomes, it seems, close to impossible. For instance, a teacher in one of my stress workshops revealed that she had recently been diagnosed as having a serious illness and her spouse, who was suffering from emotional problems, continued to need her support. She chose to continue teaching and she felt that her fellow teachers were a much-needed support group. In this case, rather than wallowing in self-pity, she continued a career which provided her with an anchor and a sense of purpose and contribution. Life--is it a threat or a challenge? Again, the answer is a matter of individual viewpoint and involves courageous, conscious decision-making.

In terms of life-coping techniques, it happens that the stuff of science--the scientific method--becomes a problem-solving tool. The steps of making observations, gathering data, forming hypotheses, testing hypotheses, and making tentative conclusions can be translated into the following problem-solving model:

1. Identify the problem.

2. Formulate at least two-three possible, tentative solutions to the problem.

3. Analyze the value of each tentative solution.

4. Choose the solution which seems best suited to the problem.

5. Give a time commitment to that solution.

When science is viewed as a vehicle to help develop overall coping skills, it becomes less of a threat and more of a useful tool--a tool which can help people to move from the basic survival mode into the liberating world of growth. However, when the methods and materials of science itself contribute to teacher anxiety, the teaching of it becomes overwhelming when combined with overall teacher personal concerns. No wonder teachers shy away from teaching science. Science has never been a real help to them!

The DARE Chart--Using the Scientific Method

One means of allowing teachers to experience the scientific method in their own lives has been used successfully in stress workshops. The key to success is the teacher's own decision to become a change agent in his/her life. Using a DARE Chart (Direct Action to Risk Enrichment) (Figure 1) developed by the author (Betkouski, 1981) as an attempt to help teachers to keep track of their perceptions, each teacher lists five sources of stress in his/her life along with an emotional (mind) reaction and a physiological (body) reaction to the stresses. For instance, in the area of elementary science teaching, the teacher might list as one source of stress, "lack of knowledge of how to do science." In this regard, an emotional reaction to this perceived deficit could be panic and anxiety during a science lesson and a physiological reaction could be a headache or tight stomach.

Awareness of stressor and reaction begins a process which includes, next, group support. Small group (four to five teachers) brainstorming allows each teacher to find possible, tentative solutions to his/her problem. In the case described, two solutions might be (1) enroll in a basic science course at your local college or (2) work with a science resource person in planning lessons. The last two columns of the chart are filled out by the teacher when she/he chooses one of the problem solutions and gives it a chance by trying it out for a certain period of time, e.g., two months. If it works, hurrah! If it does not, the teacher can resort to another solution or solutions determined by the group. The time line assures a commitment and the taking of positive steps to solve the problem. The tentative nature of the solution is in line with the tentative, tolerant nature of science itself.

DIRECT ACTION TO RISK ENRICHMENT

SOURCE OF STRESS	EMOTIONAL REACTION (MIND)	PHYSIOLOGICAL REACTION (BODY)	COPING MECHANISM	TIME LINE

Figure 1. "Dare" Chart

Growth--Beyond Survival

It is to the area of growth that we will next progress. Growth depends on both a strong self-concept and an opportunity to grow. Perhaps in no other profession is a healthy sense of self quite as important as in teaching. In ways that are becoming increasingly clear through techniques such as neurolinguistic programming (Bandler and Grinder, 1979), one person's influence on another as a result of verbal and nonverbal interaction is staggering. Teachers affect their students in ways of which they are never really aware. The old question about which teacher has made an impact on a person's life yields answers that show deep effects on personal and career direction. I will never forget the teacher who criticized my writing style in front of the class. I have been determined to prove her wrong ever since!

Developing a Concept of Self

The findings of a study conducted with 88 teachers enrolled in a graduate course in an eastern university suggest the following:

> If a teacher has not been helped to develop a sense of self-esteem, and has not been exposed to a process of learning to use oneself as an instrument for relating constructively with children, then that teacher will be less likely to feel able to practice or impart the value of interpersonal caring to others--a value central to the mental health of all developing humans (Wolf and Schultz, 1981, p. 70).

Most teachers enter the profession wanting to grow and desiring to help their students to do the same. When that growth does not seem to be occurring, discouragement, even cynicism, sets in. Is there a way to circumvent this process or is it naturally occurring? Actually, discouragement can be a healthy aspect of growth. If viewed as a signal for action, a teacher may decide to analyze reasons why growth is not occurring and look for ways to promote it. In addition to the earlier admonition, "teacher, teach thyself," comes an even more fundamental bit of advice, "teacher, know thyself and thy limits!"

Elementary school teachers have legitimate concerns as to where their strengths and weaknesses lie in teaching individual subjects and in teaching as a whole. There are numerous cases where earned pre-service grade point average does not coincide with either true or perceived effectiveness in the classroom! Academic courses, even when coupled with field experiences, do not mirror actual teaching; further, success one year does not guarantee success in the following year. The number of variables in the space between the teacher teaching and the student learning can be crushing.

Controlling Variables

Given that all variables cannot be controlled, at least the teacher can develop a fair sense of where she/he is coming from. Personality and life-style information can be helpful. Studies, such as those conducted with the Myers-Briggs Type Indicator (MBTI) yield information about which personality types choose certain professions or, within teaching, which types choose which grade levels and/or subject areas (Hoffman and Betkouski, 1981). These choices can be compared to our own. For instance, most elementary teachers show a preference for being organized. A person who chooses to ignore order in the classroom could suffer the stress of chaos in paperwork and classroom discipline. This does not mean that the skill of organization cannot be learned. It simply means that it is probably easier for an elementary school teacher to maintain personal and classroom sanity if she/he is organized. So, if one's personality includes a repugnance toward order, elementary school teaching can be difficult. This is a useful piece of personal data. A word of caution must be interjected about personality indicators as they apply to teaching. There is no one perfect teacher personality! We need all types to meet the needs of the diversity in our students. So, again, gathering data about our personalities can be useful, but only the individual should decide how it is to be used.

In the area of life-style, it would be wise for the teacher to list life goals and priorities and see if the life of a teacher fits the list. Teaching involves delayed gratification and patience and usually does not include a grand plan for giant financial leaps. Needs in the area of life-style should be considered carefully. Not everyone should teach!

Assuming, however, that one has made the decision to teach elementary school, another concern might be ability and willingness to handle innovation. If a new science curriculum is introduced, how and under what condition is the teacher willing to accept it? James (1982) has discussed the usefulness of a model for teachers and change facilitators which was developed by Hall and colleagues at The Research and Development Center for Teacher Education at the University of Texas at Austin. The stages of concern reflect the amount of commitment which a person will offer to an innovation and are reflected in Hall's model, the Concerns Based Adoption Model, CBAM. Obviously, attitudes and perceptions about the change are critical factors which underlie acceptance and implementation of a change. CBAM reflects earlier findings by Frances Fuller, who studied concerns of teachers from pre-service days to professional teaching years. She found that concerns were developmental in nature, beginning with concern about self, moving into concern about task or job, and culminating in concern about impact. Similar categories of concern are reflected in the seven stages of the CBAM model. The stages are summarized below.

Concerns About Self:

0. Awareness--I am not concerned about the innovation.

1. Informational--I would like to know more about it.

2. Personal--How will using it affect me?

Concerns About Task:

3. Management--I seem to be spending all my time in getting materials ready.

Concerns About Impact:

4. Consequence--How is my use of the innovation affecting kids?

5. Collaboration--I am concerned about relating what I am doing with what other instructors are doing.

6. Refocusing--I have some ideas about something that would work even better.

Concern About Science (adapted from Hall and Rutherford, 1976, P. 229)

Let us apply CBAM to the learning of science and to science teaching. If a teacher has not worked through the "self" concerns about science study, it is unlikely that she/he will be concerned about organizing science lessons and the impact of science curricula on the students. Adjusting the curriculum creatively to meet the needs of his/her students will not occur. So, it is no wonder that science ranks so low in the list of time devoted to individual subjects. We need to develop interventions at each stage of the concerns model geared to helping teachers to nurture interest in science and the teaching of it.

Just as the development of interests in general aids in the strengthening of self-concept, so, too, will generation of interest in science lead to an improved science self-concept. It is crucial to deal with insidious science-anxiety as soon as possible. One factor which perpetuates science anxiety is the sad fact that basic science skills were never learned. If a teacher feels anxious about teaching science, she/he will surely increase the chances for producing science anxious students. Sometimes science anxiety is so deep that special approaches need to be used to overcome it. Science anxiety clinics at the undergraduate level have been used successfully to help students to deal with science anxiety. One model program at Loyola University in Chicago has been described by Mallow (1981). Students work with both a counselor and a scientist to attain the realization that science is indeed a human venture and comprehensible.

My own experience with undergraduate elementary science methods students indicates that, in addition to science anxiety, there exists a "feeling" that science is dull and boring. Several students were indeed surprised to find that science can be fun! They were even more intrigued with the potential application of the scientific method of problem solving to both science-related problems and their real-life dilemmas. Visualizing the study of science as something which helps rather than hurts can stimulate movement from concern about self (just making it through a science lesson) to concern about one's own involvement in making science exciting for one's self and one's students.

Unique individual concerns

Although our discussion of personal concerns of elementary school teachers covered several general categories of concern, it did not pretend to generalize about the unique nature of individual concerns. These we must sort out in our varied and creative ways and according to our own value structures. Science, by its very nature, aids in that process. We do have immense creative potential. As Norman Cousins (1981) states in his fascinating book, Human Options:

> Science and common sense converge in the ultimate mission of human intelligence--the full potentiation of the individual. This process is not confined to the development of human ability. It involves in equal measure the way human beings ward off breakdown and cope with it when it occurs. It has to do with the will to live and the physiological benefits of creativity and the positive emotions. It assigns proper value to hope, faith, laughter, and confidence in the life force" (p. 206).

Career Match--Should I Teach?

It is time to consider elementary teacher career concerns. That these cannot be separated from personal concerns might seem obvious, but there are indeed times when the career and the person do not appear to be well integrated. Perhaps the chief career concern of most people is whether that integration can, indeed, occur. Should I teach?

What are most of us looking for in a career? I have chosen to divide the search into three areas: personal satisfaction, reward structure, and acceptance. Is teaching a satisfying career? Our first inclination might be to answer in the affirmative. After all, teachers are giving of themselves to help others to learn. Is there a more noble profession? Let us designate that question as rhetorical and study a few statistics related to teacher job satisfaction. A recent NEA opinion poll confirms what facilitators are hearing in stress management workshops 45--percent of the teachers surveyed nationwide said they would not choose teaching as a profession again! One of the reasons they give for this is stress (Muse, 1981, p. 45). In like fashion, a survey among more than 400 K-12 teachers in a middle size midwestern school system pointed out the following:

> Almost 55% of the respondents indicated that a career change had been considered in the last two years. Only 33% of the respondents would encourage, 47% would neither discourage nor encourage, and 20% would outright discourage a student to enter the teaching profession (Dedrick, Hawkes, and Smith, 1981, p. 33).

Correlates of career satisfaction

A person contemplating a teaching career would, no doubt, not be overly excited about those statistics. Of course, there are those teachers who would not trade the teaching career for any other. What are some correlates of career satisfaction that perhaps need to be strengthened in teaching? The teacher's perceived level of influence, level of contribution, and level of knowledge expansion appear to be important factors in the area of career fulfillment. Studies show that the more influence a person has over his/her fate, the less stressed and happier the person tends to be. If the teacher is a mere robot, teaching in ways in which she/he has very little input, that teacher is apt to feel pressured and confined.

To alleviate this problem in the teaching of science, local teaching staffs should develop clear philosophies for science education and have input into the total K-12 goal structure, balancing process skills, knowledge, and contemporary science issues. Even specific time allotment for science teaching should be determined by staff input, e.g., 100 minutes per week for grades K-3 and 150 minutes per week for grades 4-6 (Gerlovich, Downs, and Magrane, 1981). A teacher must not feel like a puppet whose strings are being pulled by school district edict. Creative juices do not flow that way, especially if the teaching

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of that subject, science in this case, is already a cause for anxiety. Fate control in teaching is essential if teachers themselves are to be positive role models and change makers. This emphasis on the teaching act is crucial. Although we would hope that teachers teaching science have a positive attitude toward science, that attitude alone does not predict science teaching behavior. Apparently, personal interest in teaching science and attitudes toward teaching science and children learning science are more fruitful predictors. (Sunal, 1982).

Does the elementary school teacher, especially the teacher teaching science, experience a sense of contribution and knowledge expansion? Whether or not this occurs, no doubt, depends on the teacher's science self-concept, interest in science, and interest in having students learn science. The science literacy of our society in general is not at all adequate. We need to have our teachers develop that literacy to a reasonable level. The teacher must be convinced that science is exciting and worthwhile. Intimidation in this field will not motivate a teacher to pick up a book and read about the fascinating world of the brain, for instance! We must promote the notion that science is both "friendly and fascinating."

Reward Structure

We choose careers out of interest, but also as a source of both spiritual and financial reward. We have discussed the kinds of growth possible in the teaching profession which are connected to the realm of the spirit. Less ethereal, but certainly related to survival and career decision making, are the financial incentives in teaching. These are, to say the least, not abundant. Would extra financial incentives make a difference in the teaching of science? By themselves they might suffer the plight of so many of the science kits in elementary school storerooms--nicely polished packages of temporary gratification, signifying "not much" without direction. It is not enough to pump extra monies into science teaching without connecting those monies to needed professional incentives and follow-through. Interaction, a basic science concept, applies in the area of science teaching, too.

We, no doubt, should face the fact that not all elementary school teachers will decide, even with extra training in the glories of science, that teaching science is their favorite thing! However, we must assure that good science teaching is happening in our schools. Several states are beginning to make recommendations which include professional and financial incentives to upgrade science teaching. By way of example, the Florida Association for the Education of Teachers in Science (FAETS) has made, among others, the following suggestions for upgrading elementary school science:

1. Create a certification area for teachers of elementary school science.

2. Create a position of science specialist to teach science in the upper elementary grades.

3. Create a position of a science resource teacher for the lower elementary grades.

Further suggestions for improvement of science at all K-12 levels include:

1. Encourage continued professional development with tuition reimbursement, stipends, and released time for taking college science courses.

2. Create summer institutes with special science courses for teachers funded with block grant funds and industrial grants.

3. Create summer jobs in industry for science teachers.

4. Give science teachers extra pay for helping students with after-school science projects.

5. Provide a pay differential for science teachers. (FAETS Newsletter, 1982)

There is no one realistic nationwide panacea for science teaching improvement. The states and districts themselves, in concert with teacher preparation institutions, must consider their needs and devise workable plans to meet them. Other aspects of professional career reward systems should include in-service workshops which really begin where teachers themselves are at the moment, cognitively and affectively; district-wide "R & R," (reinforcement and recognition) for teachers who are innovative; flexible teaching schedules which allow teachers to share ideas and team-teach; use of resource personnel; support of district- wide materials resource centers which would allow quick delivery of living and nonliving materials to the teachers; and interdisciplinary teaching plans. Science competency works in tandem with reading skills competence with proper instruction. In fact, the theme of interaction fits again as we devise creative ways to link science with mathematics, social studies, language arts, art, music, and almost anything that comes under the umbrella of the elementary school!

One final career concern is acceptance by self and by others. How we see ourselves affects how others see us and, often, the converse is true. Teaching should be one of the highest status occupations; it must not be reduced to a routine "maintenance" job. Teachers are in the business of perpetuating wellness through a love of learning, through inculcating a zest for exploring the unknown, and through positive human interaction. Let the profession believe in itself that others also might believe in us. We, as educators, must take the initiative; we must help one another. Two important dimensions of helping relationships are called responding and initiating (Carkhuff, Berenson, and Pierce, 1976). Responding means using statements that show we understand how another feels. Initiating means helping another to understand where she/he wants to be. A good helping response to a teacher lamenting the teaching of elementary science might be the following:

> You feel discouraged and frustrated because science isn't being taught the way it should be (responding); let us all pool our ideas, use divergent thinking, tap unused resources and believe in our collective ability to have science perceived and taught as one of the most basic of skills (initiating).

CONCLUSION

Only through cooperation will our personal and career concerns be met and will the teaching of science in the elementary schools become a vehicle for survival and growth of both teacher and student. If you go away from the reading of this chapter and do just one thing to effect better science teaching (write one letter to a state legislator or praise a science teacher, etc.), we will have made an important first step nationwide in setting up a needed network of support for elementary science teaching. Go for it!

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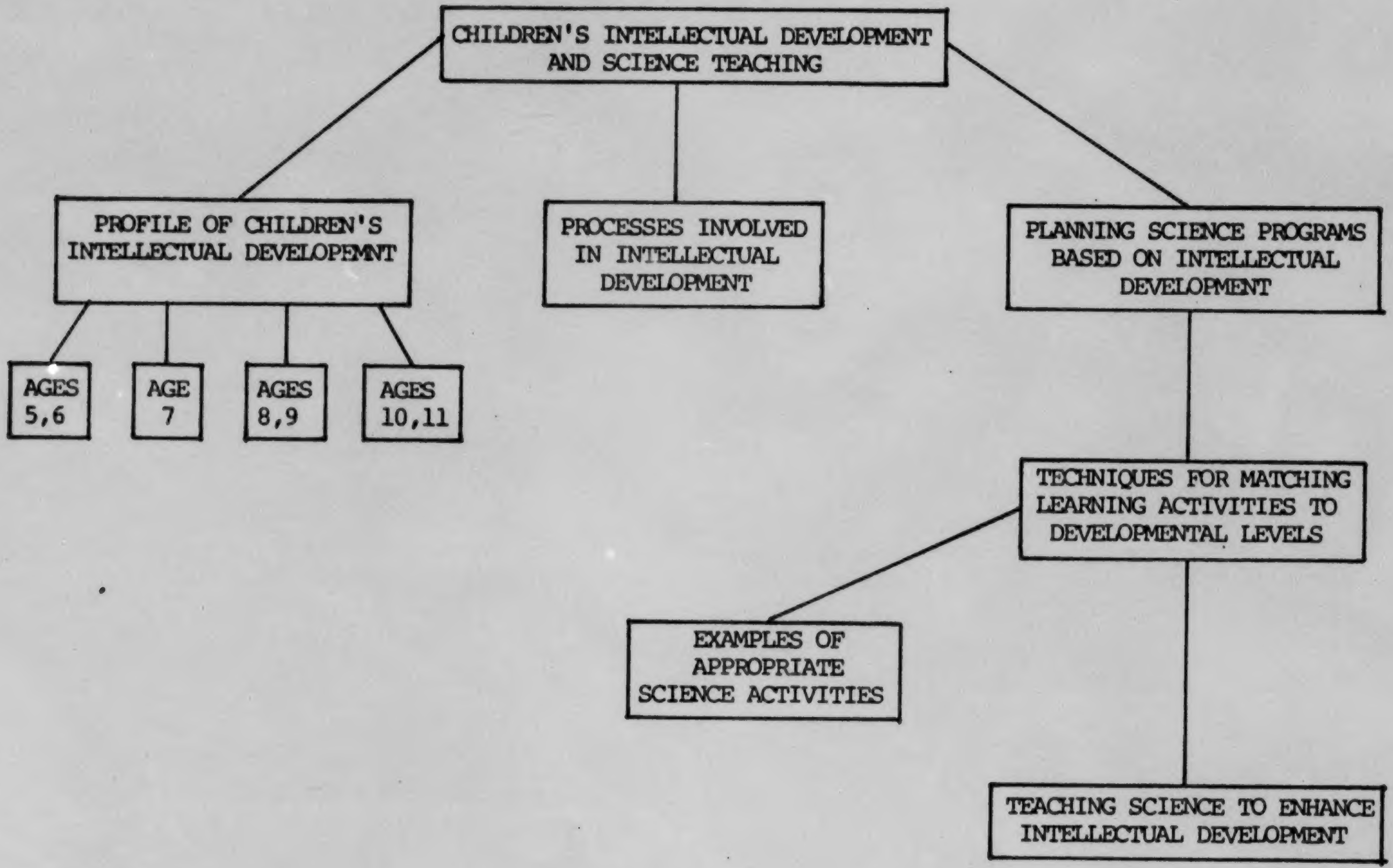
CHILDREN'S INTELLECTUAL DEVELOPMENT AND SCIENCE TEACHING
PROFILE OF CHILDREN'S INTELLECTUAL DEVELOPEMNT
PROCESSES INVOLVED IN INTELLECTUAL DEVELOPMENT
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AGES 5,6
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TECHNIQUES FOR MATCHING LEARNING ACTIVITIES TO DEVELOPMENTAL LEVELS
EXAMPLES OF APPROPRIATE SCIENCE ACTIVITIES
TEACHING SCIENCE TO ENHANCE INTELLECTUAL DEVELOPMENT

CONCEPT MAP: CHAPTER 7

CHAPTER 7

SCIENCE TEACHING AND CHILDREN'S INTELLECTUAL DEVELOPMENT

Alan J. McCormack

INTRODUCTION

Do children "see" the world and think differently than adults? How does the thinking of a pre-schooler compare with that of a third- or sixth-grader? Do children's minds develop in predictable ways? And, can school science programs influence mental development of youngsters? These are some of the most fundamental questions facing those who develop science programs for elementary schools.

Much is left to be learned about children's intellectual development and the current state of the art has probably not delved much below the proverbial "tip of the iceberg." But, through decades of informal observation of children in schools, and trial and error attempts at introducing various learning tasks at differing grade levels, curriculum developers have a reasonably good "feel" for what children do at various age levels. This "seat-of-the-pants" approach has probably been better than most of us would admit, but it is certainly not good enough. We do need carefully designed observations of children's perceptions, thought processes, and other psychological characteristics on which to base science programs.

Before writing this chapter, I looked as extensively as I could into the literature of children's intellectual development to try to find recent, exciting alternatives to the Piaget-initiated approach to studies of young minds. I found no better alternative. No other individual has asked more questions and compiled more data regarding children's intellectual development than Jean Piaget. Through the research efforts of his hundreds of followers, reasonably reliable profiles of human mental growth are now available.

As most science educators are well aware, Piaget has come to be mainly associated with his proposed four stages of intellectual development: (1) sensory-motor (0-2 years), (2) pre-operational (2-7 years), (3) concrete operational (7-13 years), and (4) formal operational (13-16 years). Unfortunately, these stages have come to be too narrowly interpreted and considered as "gospel truth" by some educators, rather than as the very general indicators of development intended by Piaget. Each cognitive stage, in actuality, is associated with a far wider age band than is ordinarily specified, and several studies indicate that a significant number of people never completely attain formal operations (Ross, 1974; Elkind, 1961; Schwebel, 1975). To classify a child in the concrete operations stage only means that most of his interactions with the physical world are characterized by concrete operational thinking. The same child is likely to deal with some problems at a preoperational level and may even be able to deal with some situations in a formal operational way. Development is clearly a continuous process, but it is also subject to wide variation within groups of children. Piaget's stages are age-related, but not age-fixed. The stages are reliable in a probabilistic way--the probability is high that a 3- or 4-year-old will reason about a problem in a characteristic way and that a young adolescent will use very different reasoning processes when faced with the same problem. And, although various mental operations cannot be absolutely predicted to appear at a certain age, we can fairly accurately predict that mental operations will develop in a sequence within clusters of thought patterns. Within the cluster of conservation abilities, for instance, conservation of substance invariably develops before conservation of weight, while conservation of volume develops after conservation of weight.

To design elementary science curricula that are genuinely appropriate for children, it would seem eminently reasonable to first identify the general bands of intellectual ability present in children in each of the elementary grades. Then, learning activities and concepts within the scope of what children can reasonably be expected to deal with should be carefully selected. Wide discrepancies between the intellectual requirements of learning tasks and the developed abilities of learners should obviously be avoided. Toward these ends, I have compiled a very rough and rudimentary general profile, grade by grade, of "typical" children's development. The profile is interdisciplinary--it samples from cognitive tasks required in many of the subjects taught at the elementary level. This scheme has been based on both research by Piagetians and the wisdom of experienced classroom teachers. The list is not sacred and is certainly open to criticism, modification, and refinement. I intend it as a first draft description, rather than as a stone-engraved manifesto. If it is changed and enlarged by others who find it useful, it will have served its purpose of highlighting the crucial question: What learning is appropriate for children at different grade levels?

A GENERAL PROFILE OF CHILDREN'S INTELLECTUAL DEVELOPMENT

Ages 5 and 6--Kindergarten and Grade 1

Youngsters are in the late phases of an intuitive phase of development--the stage of preoperational thinking. They cannot generally be expected to perform logical mental operations, though the rudiments of certain operations are developing and children should be given direct experiences with fundamentals of some operations. (Operations are logical processes such as combining objects as in adding, placing things in order by length, or doing "if-then" thinking.)

Some Cognitive Competencies Developed in Preoperational Children

Preoperational children are not consistently capable of carrying on rational processes. That is why they sometimes say things that appear funny to adults. Here are some general characteristics usually attributed to this age group:

1. Children cannot consistently perform mental operations but language develops. A tremendous development of vocabulary occurs.

2. The ability to "internalize" actions has developed--children can form mental images of actions. For instance, they can think of moving an object before they move it. However, their mental images are limited to what they have experienced.

3. Preoperational children tend to center on one dimension or variable of a problem and typically cannot decenter (see another significant variable involved in the problem). An example of child-centering is apparent in the classic Piagetian task of rolling a clay ball into a sausage shape. The preoperational child typically does not realize that the amount of clay remains the same.

4. Seriations and transformations of objects are typically not mentally processed. These are confusing to this age group because their minds tend to focus on individual states in a series of events. For this reason, teachers find it

difficult to communicate instructions to this age group if the instructions involve following a series of steps. Usually tasks must be approached one step at a time.

5. Thought processes are generally not reversible. For example, if asked "What is a duck?" a youngster will say "It is a bird." Then if asked "What would happen if all birds were killed? Would there be any ducks left?" the child is quite likely to reply "Yes." He/she does not realize that the subclass "duck" belongs to the class "bird." The child conceives of subclass and class but then is not able to reverse his/her mental process to go from class to subclass.

6. Animistic and artificialistic explanations are common: the sun moves because it wants to; the moon moves to follow the child; mountains are made by giants; all things are seen to be oriented toward human purposes and motives.

7. Egocentrism is common--it is difficult for preoperational children to see things from the points of view of other people.

8. Beginning conception of time develops--youngsters can go beyond the immediate now to some thinking of past and future, but not very far in either direction. Time on a clock has almost no meaning at all.

9. Conceptualization of space is limited to local, directly-experienced places: home, yard, neighborhood, school. Meanings of "city," "state," and "country" are not comprehended.

Some Cognitive Competencies Developed in Kindergarten

- counts by rote from 1-10
- can correctly assign a number to sets of objects up to five objects
- recognizes numerals 1-10 when presented in random order
- identifies whole and half objects
- follows simple directions to complete one task ("Take one crayon")

- can name basic human body parts (eye, nose, elbows, chest, etc.)
- names basic geometrical shapes (square, triangle,
- names basic colors--red, green, blue, yellow, orange, purple, black, brown
- begins to describe properties of objects (rough-hard-soft, flat-round, etc.)
- explains use of objects and pictures of objects (e.g. a broom is for sweeping)
- can observe and report present weather conditions (rainy, sunny, cloudy, etc.)
- begins classification skills (grouping objects by a single characteristic such as color, shape, or size)
- writes first name legibly (manuscript)
- can draw a circle, vertical, and horizontal lines, and uses crayons to color large areas (typically with some scribbling over lines)
- can properly associate orally presented words with pictures and drawings

Some Competencies Developed in Grade One

- counts from 1-20
- compares sets of objects (more than/less than)
- identifies and uses symbols (+, -, =)
- solves addition problems involving sums up to 10
- counts by 10s to 100
- conserves number
- recites nursery rhymes with understanding
- can correctly discriminate among pairs of sounds: loud and soft, high and low pitch, fast and slow rhythm

- retells, in proper sequence, a short story read aloud several times by the teacher
- names parts of objects (a chair has legs, a back, and a seat)
- further expands vocabulary of names and properties of objects
- learns more basic shapes (star, diamond, oval, rectangle, heart)
- recognizes and uses vowel and consonant sounds and blends
- understands placement in space of objects in terms of over/under, before/after, up/down/between, in front of/in back of, away from/toward
- duplicates the order of a sequence of pictures, designs, or beads presented by the teacher
- discriminates between solids, liquids and gases (can learn some properties of each state)
- seriation ability develops in second semester of Grade 1 (can order five objects from smallest to largest, shortest to longest, etc.)
- uses scissors to make reasonably accurate cut-outs of simple paper shapes
- writes (manuscript) first and last name legibly; copies words in basic sight vocabulary correctly
- reads single words and simple sentences from a vocabulary of a few hundred words

Age 7--Grade 2: A Key Phase in the Development of Logical and Creative Intelligence

Age 7 marks a transition from preoperational to concrete operational thought. The period of concrete operations spans, on the average, ages 7-13, thus including most elementary school children. {new

General Concrete Operational Stage Characteristics

1. Children develop abilities to think logically--to use mental operations of addition, subtraction, conservation, division, multiplication, seriation, and reversibility. But they require concrete reference objects when carrying out mental

operations. They cannot carry out abstract reasoning processes such as symbolic logic. They also are not able to understand in detail or in depth abstract science concepts such as osmosis or photosynthesis.

2. A great spurt in the ability to use infralogical operations develops (The word "infra" in Greek means "below"). Piaget considers infralogical operations to be mental processes below operations in the degree of mental sophistication and development required. However, these infralogical operations are not well-developed until children grow through age seven. Infralogical operations are sometimes called "process skills." They include:

   Observation
   Measurement
   Understanding time
   Classification
   Understanding spatial relations
   Awareness of interpersonal relationships
   Establishing values

3. By the end of the concrete operations period (12-13 years or older) youngsters conserve substance, length, number, area, weight, and volume. However, these abilities are developed gradually and in a heirarchy. Conservation of volume, for example, may not develop until age 12 or 13.

4. Hypotheses are possible--concrete operational youngsters are able to formulate hypotheses related to scientific problems. Typically, however, they are able to suggest only one hypothesis involving a single variable. (Suggesting multiple hypotheses involving several variables is characteristic of formal operational youngsters).

Some Cognitive Competencies Developed in Grade 2

- counts and writes numbers to 100 (by end of this grade level)

- can do subtraction problems through 99 without regrouping

- conserves length, liquid, and solid amounts

- tells clock time to the hour

- adds through 99 without regrouping
- identifies colors that are blends of other colors (pink, gray, tan, aqua)
- names the days of the week and months of the year in sequence
- can easily give many examples of subsets included in classes, e.g., 10 animals, 10 kinds of foods, etc.
- can understand a class may have many different subclasses
- begins to comprehend a logical argument or explanation
- can sort pictures into living and nonliving things
- can write sentences and paragraphs legibly from dictation
- can draw realistic sketches of observed living things and objects
- can comprehend simple, observable causal relationships (but not abstract causality such as molecular interactions or Bernoulli's principle)
- can begin to visualize actions on objects that have not been previously experienced
- can remember and understand a sequence of steps (directions) up to three steps
- begins to see things from the viewpoints of other people

Ages 8 and 9--Grades 3 and 4: Experiencing Concrete Operations

Early concrete operations brings a number of new achievements in a relatively short time: children now have developed a reversible system of mental operations, enabling them to construct stable hierarchies of classes and to conserve quantity, number and some aspects of space and time. According to Piaget, a whole new cognitive organization underlies the child's new conceptualizations. Before concrete operational thought the child's images are like static snapshots--with concrete operational thought they become more like smooth moving pictures. Youngsters can now visualize the stages in a transformation or movement of an object, rather than focusing only on beginning or end states.

Some Cognitive Competencies Developed in Grade 3

- adds and subtracts two- and three-digit numbers using regrouping
- multiples one-digit numbers
- learns simple division facts
- reads clocks
- makes changes with coins and bills up to $2.00
- learns fractions 1/2, 1/3, 1/4, 1/5, 1/6
- learns rudiments of measuring systems (feet/inches/yards, centimetres, cups/pint/quart)
- reads thermometers (Fahrenheit and Celsius)
- can read simple bar and circle graphs
- when told a scrambled version of a familiar story, retells the story in proper sequence
- can give directions for a game to other children
- names and places proper directions on a map (N., E., S., W.)
- can imagine "what might be if"
- reads books for young children very fluently and with understanding
- cuts complicated patterns with scissors
- colors with crayons strictly within borders of figures
- learns cursive writing

Some Cognitive Competencies Developed in Grade 4

- reads clocks in minutes
- multiplies two- and three-digit numbers by one digit numbers, with regrouping
- divides two- or three-digit numbers by one-digit numbers (with and without remainders)
- when presented with verbal arithmetic problems, can tell whether to add, subtract, multiply or divide to solve the problem
- can properly place 1/5, 1/6, 1/7, 1/8, etc. on a fraction line and tell which is relatively larger or smaller
- recognizes English measures of length (inch to mile) and weight (i.e., mass, ounce to ton), and metric length (millimetre, centimetre, metre, kilometre) and weight (grams to kilograms)
- adds simple fractions with common denominators
- follows 5- and 6-step directions
- can visualize relative positions of objects as seen from the point of view of another person
- identifies antonyms, synonyms, homonyms
- identifies root words, prefixes, and suffixes
- can proofread a short story indicating some errors in spelling, punctuation, margin indentation, and capitalization
- uses cursive writing in daily work
- can write own stories and descriptions of experiences
- can understand the logic of a controlled experiment involving manipulation of a single variable

Ages 10 and 11--Grades 5 and 6: Late Concrete Operations

Early concrete operations (grades 2, 3, 4) were marked by the emergence of logical classification, conservation, and the reversible mental coordination of two spatial dimensions. A child reaches late concrete operations when he/she has demonstrated the use of arbitrary measurement units, horizontal and vertical spatial coordinates, and good ability to visualize spatial perspectives. Understanding and design of controlled experiments may be expected if the experiments focus on concrete objects and situations. Complex abstractions, such as density or the electromagnetic spectrum, are not understandable for this group because they are not demonstrable as concrete objects. However, some good logical and creative thinking can be expected if problems or topics directly relate to observable objects.

In late concrete operations, egocentrism declines markedly, spatial and social perspectives increase, value hierarchies begin to achieve stability, and a new social consciousness develops.

Some Cognitive Competencies Developed in Grade 5

- reads whole numbers through millions
- estimates sums, products, differences and quotients
- applies arithmetical skills to story problems
- reads decimals through thousandths
- adds, subtracts, and multiplies decimals
- converts improper fractions to mixed fractions
- adds fractions with different denominators
- computes areas of rectangles
- makes predictions based on cause-and-effect relationships involving concrete references
- readily uses concrete models in explaining scientific phenomena
- develops good skills in using hand tools for construction projects
- conserves solid volume

Some Cognitive Competencies Developed in Grade 6

- divides whole numbers by 2- and 3-digit divisors
- compares and orders fractions
- applies division of fractions to story problems
- multiplication and division of decimals
- writes small whole number ratios and proportions
- solves percentage problems
- reads and writes Roman numerals
- finds volume of rectangular solids
- may conserve displaced volume
- improves visualization abilities
- begins to offer multiple hypotheses involving more than one variable when confronted with scientific problems
- readily uses the idea of reversibility
- can develop a hierarchical classification scheme for large sets of objects
- develops a rudimentary notion of probability

PROCESSES INVOLVED IN INTELLECTUAL DEVELOPMENT

Intellectual development, in terms of Piaget's model, is a process of continuous adaptation and organization. All intellectual development involves interaction between a learner and his or her environment. Adaptation, to Piaget, is seen as a temporary equilibrium state, while intellectual organization involves units called "schemas." Schemas are defined by Piaget (1960) as repeatable psychological units of intelligent action. They are existing major cognitive structures or strategies the individual has available for dealing with environmental conditions.

Intellectual adaptation is a self-regulating balance between processes of assimilation and accommodation. Assimilation involves taking information in from the environment and incorporating it into invention of new schemas, or modification of existing schemas, in adjusting to assimilated information.

Intellectual development is initiated when a discrepancy is experienced between an existing schema and a newly assimilated bit of information. Disequilibrium results, and accommodation reconstructs a schema so that the new informational input "fits." So, for Piaget, mental development is active structuring of experience. He wrote that:

> Knowledge is not a copy of reality. To know an object, to know an event, is not simply to look at it and make a mental copy, or image, of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand this process of transformation, and as a consequence to understand the way the object is constructed (Piaget, 1964, p. 8).

A developmental "stage" in Piaget's theory is a complex of a large set of schemas that are in a relative state of equilibrium at some point in a child's development. As development proceeds, earlier stages are modified and integrated into later stages in a predictable order of succession. And, the fuel that powers these changes is a mix of disequilibrium and direct action on objects. For development to occur, there must be some mismatch between experience and existing schemas. But, if the mismatch is too great, development is thwarted. So, the key to effective planning of science learning activities is to find just the right small degree of discrepancy between a student's existing schemas and a new learning experience.

Planning Science Programs Based on Intellectual Development

Science programs traditionally have tended to require children to develop concepts and perform cognitive tasks before they are developmentally ready to do so. Kindergartners and first graders, for instance, have frequently been "taught" about motions of earth, moon and other celestial bodies in space, while their visualization abilities are limited to a here-and-now-from-my-own-point-of-view perspective. A first-grader may be ready to begin developing spatial perspective about his or her own immediate neighborhood, but the solar system is probably far removed from the child's realm of comprehension. Curriculum developers have long been quick to operate as though a child's understanding of a scientific phenomenon can be assumed if the youngster uses correct words in making verbal explanations. Interviews of children in the style of Piaget, however, frequently provide convincing evidence that children's explanations are simply repetitious of adult language and are quite inconsistent with genuine conceptions in the mind of youngsters.

As indicated in the "Profile of Children's Intellectual Development" given above, children's ideas and thinking skills change enormously between kindergarten and sixth grade. These changes are gradual and continuous, varying immensely from individual to individual, but forming general patterns that can be identified when the thinking of large groups of children is studied. One convenient, and useful, description of these general developmental patterns, is the scheme developed by Piaget. And, Piaget's clinical interview technique, the method used to accumulate the data from which his stages were inferred, appears to be the best tool developed so far for determining the appropriateness of scientific ideas and activities for various grade levels. In designing science programs, I would recommend that curriculum developers:

1. Continue study of the natural state of children's conceptions of the world and thinking abilities at various ages. At each age level, of course, there is a spectrum of abilities; but ways of thinking of a thirteen year-old are certainly quite different from thinking processes of a five year-old. We need extensive maps of the minds of typical children to guide our selection of science program components.

2. Evaluate components of existing science programs by interviewing children concerning their interests, conceptions of the world, interpretations of scientific information, and ability to perform prescribed learning activities. Discard curricular components that are found to be inappropriate.

3. Avoid development of verbalistic "scientific" explanations by children. Instead, focus on children's personal perceptions and explanations of phenomena.

4. Expect children to apply various logical operations in science learning activities only when they are developmentally ready to do so.

5. Give children a part in choosing at least some problems or topics to work on. Direct experiences are needed by children as they develop from one form of thinking to another. The best person to select experiences suited to a child's mental development and personal interest is the child.

6. Design science activities to assist children in developing their own thinking abilities.

7. Be sure that science curricular components enhance, rather than degrade, students' conceptions of their own abilities to think.

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8. Ensure that learning of science is something done by, not to, the learner.

9. Realize that cognitive and affective dimensions of learning are intermeshed. Learning activities should be perceived by children as interesting, enjoyable, and of value.

10. Be aware that cognitive development is a transdisciplinary process. Intellectual skills appropriate to science are also integral in language, mathematics, art, and social studies. Thus, elementary science should be related and applied to other school subjects.

Matching Science Activities to Intellectual Levels

We probably will never completely understand how children think at various stages in their development. But we are learning more about children's thinking each day, and we can presently make reasonable matches between science activities and children's capabilities. Though totally objective, quantitative procedures for this matching process are not currently available, reasonably good connections can be made between what is known about children's capabilities and the appropriate design of science learning tasks. At present, the best method for accomplishing suitable matches between science and children is through probing the thinking of individual children with Piagetian-style interviews (though not necessarily using the classic Piagetian tasks). Curriculum developers can learn much by using the questioning approach of Piaget while working through science activities with children. This process has been used extensively and effectively by the Schools Council of Great Britain in developing the Science 5/13 elementary science program (Ennever and Harlen, 1972) and by Shayer and Adey (1981) for determining appropriateness of science concepts for secondary school students. As an instructor of elementary science teaching methods courses for the past 14 years, I have found the science activity/Piagetian interview combination to be a powerful way to acquaint prospective teachers with children's thinking at various age levels, and as a way to compile information about generalized age appropriateness of science concepts and activities (McCormack and Bybee, 1970; and McCormack, 1971).

Following are some samples of science learning tasks that have survived extensive evaluation in Piagetian interview/science lessons with elementary children:

For Kindergarten and Grade 1 (Preoperational Children)

- Have children observe and describe physical changes that take place as time passes.
- Invite children to make comparisons of single dimensions of objects (which is longer, wider, or heavier?)
- Have children group objects based on a single observable criterion
- Involve children in making observations and descriptions of properties of objects
- Give children tasks where they can place objects in order based on a single property (length of sticks or size of circles)
- Provide experiences with recognition of common geometric shapes (circle, triangle, square)
- Have children observe, and record with drawings, life cycles of common plants and animals
- Encourage children to pour water into containers of different shapes and sizes
- Encourage children to measure lengths of various parts of their own bodies by cutting strips of newspaper to match body parts
- Involve children in dramatic play using their own bodies to simulate scientific processes (life cycle of a butterfly, growth of a seed)

For Grades 2 and 3 (Early Concrete Operational Children)

- Have children observe and record variation of a single property within a group of like objects
- Have children become familiar with sources of sound and the notion that sounds are vibrations
- Encourage students to measure length and weight of objects
- Involve children in simple operational tasks (adding, subtracting, ordering) using objects collected from their local environments

- Encourage invention of imaginary creatures, places, and stories

- Have children predict changes that may take place, with time, in observed objects or systems of objects

- Involve students in recording measurements or other observations of concrete objects through the use of simple histograms

- Have youngsters manipulate and transform objects as frequently as possible (mold a piece of clay into various shapes, bend wire, pulverize sugar cubes) and compare beginning with end states of transformed objects

- Through direct experimentations, have students classify collected solid objects into "floaters" and "sinkers" categories

- Have children build structures from drinking straws and Plasticene clay

For Grades 4, 5, and 6 (Concrete Operational Children)

- Involve children in making "fair tests" of ideas through simple controlled experiments

- Do activities requiring visualization of objects from different points of view

- Have children try to visualize shapes of cross-sections of observed concrete objects

- Invent measuring systems based on standard units.

- Have students construct representational models to represent contents of "mystery boxes" that can only be indirectly observed

- Encourage children to offer several reasonable hypotheses when presented with a problem related to concrete objects

- Involve students in constructing simple scientific apparatus using hand tools

- Encourage speculation about the past and future of observed objects

- Have children construct flow-charts to represent the interaction of parts of simple technological devices (eggbeater, pencil sharpener) or Rube Goldberg-style cartoon "inventions"
- Have students list possible variables involved with problems generated from concrete situations (e.g., a potted plant has died, have students list possible causes)

TEACHING SCIENCE TO ENHANCE INTELLECTUAL DEVELOPMENT

Piaget and his followers have mainly been observers. They tried to describe the course of human intellectual development, but did not attempt to discover how school subjects should be taught to best favor development. A number of prominent science educators, though, have attempted to make classroom applications of Piaget's theory. Karplus, et al. (1977) have proposed a "learning cycle" for science lessons based on Piaget's model of self-regulation. The learning cycle includes three phases: exploration, concept introduction, and concept application.

Exploration directly involves students with physical materials with little outside direction. Students ask their own questions and frame their own activities based on their observations and manipulations of objects. Exploration is a question-finding and playful phase designed to capitalize on innate curiosity and to provide some assessment of students' initial conceptions.

During the concept introduction phase of the cycle, the teacher helps the students verbalize and order the ideas gained through explorations. This phase may also involve individual or small group experimental investigations related to questions discovered during the exploration phase.

Finally, the concept application phase allows students to apply and extend the range of newly learned ideas. This allows additional time for self-regulation and extension of student understanding.

Beyond the use of the proposed learning cycle, Karplus, et al. (1977) suggest other classroom procedures deemed useful for encouraging intellectual development:

1. Begin class discussions with discrepant demonstrations, challenges, or puzzles that cause appropriate disequilibrium.

2. Provide time for extensive and repeated experiences with objects. Students need time to resolve contradictions and to become familiar with their own reasoning.

3. Encourage discussion among students regarding the investigations they have conducted and data gathered. Encourage students to propose alternative ways of describing or explaining observed relationships.

4. Model the reasoning patterns you wish to develop. Reason out loud, and take time to work step-by-step through logical explanations.

Other science educators, notably Bybee and Sund (1982), Good (1977), and Labinowicz (1980) have recommended science classroom applications of Piaget's ideas. Some of these recommendations are:

1. Teachers should use Piaget-style clinical interviews in attempts to understand the thinking of their students.

2. Stress intellectual development of students rather than accumulation of information.

3. Adapt science experiences to where the child is developmentally.

4. Emphasize learning through activity and inductive reasoning patterns.

5. Stress verbal interaction among students in which they compare their thinking related to science problems.

6. Avoid forcing reasoning patterns on children that are too far advanced from their present intellectual stage of development.

7. Talk less and listen more. Provide adequate time for children to think and respond to questions.

8. Encourage social interaction among students as a means of decreasing egocentricity.

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CHAPTER 8

SCIENCE TEACHING AND EDUCATIONAL TECHNOLOGY CONCERNS

Carl F. Berger

INTRODUCTION

We live in an increasingly technological age. Because the results of such technology are so visible it is often blamed for the problems that confront us. Complex technological devices seem to cause more trouble than they are worth and more than once a year (once a month?) we hear the dreaded phrase "I'm sorry, I can't do anything about it, the computer made an error!" Having worked with computers for 26 years I'm certain that 98 percent of those problems are *not* computer errors but are the errors made by humans entering data into a computer. Why then do we and our students increasingly blame technological devices for the failures and problems which are all too common to all humankind? Perhaps to blame something mysterious and unknown for the problems we have is much the same as the ancient Greeks and Romans who blamed the unseen and unknown gods for both fortune and misfortune. If so, then technology today can be blamed for our misfortunes because it also is mysterious and unknown. It will remain so if we and our students don't understand the use, structure, and limits of technology and technological devices.

If, for example, we allow the dozens of computers in our lives to remain hidden and unknown then what opportunity have we to understand and in understanding control them? Part of the goals of science teaching must be to help students understand the usefulness and limitations of various technologies in the world around them and to understand how students interface with such technologies.

Science teachers must start teaching about technological concerns *with* technology rather than teaching *about* technology. The days of just illustrating or discussing how a Bessemer blast furnace works are gone. We must use, and have our students use, technological devices in our science classrooms if we are to have them truly understand how technology can control and be controlled in their lives.

THE MICROCOMPUTER

Rather than discussing all the ways all the many technological devices could be used in a science class, let's focus on one device as an example of the joys and sorrows of technology--the microcomputer. The microcomputer was chosen because of its almost universal acceptance as a new and useful device, and because it has all the problems inherent in any technological device.

Microcomputers have the potential to significantly assist students and teachers in their daily work. As an example of how such a new technology can be used, we will discuss the use of microcomputers in science instruction through simulation, calculating aids, and graphic aids. A simple program will be listed to illustrate some basic (no pun intended) ideas. The program can be entered on a microcomputer by you or your students and provide you with increased understanding of the ideas in this chapter. But first a little history.

Prior to 1978, computing by students in science classes was primarily carried out through the use of a teletype terminal connected to a computer at the central administration office. Often these computers shared instructional and administrative time. Because the hook-up was over a telephone line, students often had to go to a special place to carry out instruction. More often the computer was being used by others who had signed up earlier and was not available for student use. In 1978, the introduction of three microcomputers (PET, TRS-80, and APPLE) started a change which is still going on today. The development of an inexpensive microcomputer meant that the computer could be bought with limited funds, and because of its small size, could be brought to the place that the instruction primarily occurred. Rather than calling in to find out if the computer was being used, a glance at the corner where the computer was kept immediately told whether it was possible to use the computer. Along with these advantages there were several draw-backs. First, there were few programs available to be used on the microcomputer; second, what programs were available were often of poor quality; third, computers were often supplied without adequate instruction in their use; and fourth, educational programmers often used the large programs designed for time-sharing computers for microcomputers and complaints were heard when the programs could not fit and worked with limited success.

This poor quality led to the "90 percent rule"--that is 90 percent of the software (programs) available were of doubtful value (later this rule was modified to 95 percent--even some of the technically good programs are educationally unsound!) Teachers and students began writing their own programs to overcome this problem and often the best programs available today are those created by science teachers and students. Microcomputers were often bought by well-meaning administrators and by parent/teacher organizations with no notion as to the use of these machines. Because of previous "number crunching reputation" of computers, their use was often relegated to mathematics classes even though equally good use can be made in other disciplines that draw upon the unique capabilities of the microcomputer. In spite of these drawbacks, microcomputers remain an astounding success as a technological innovation and illustrate well the use of technology in science education.

With this bit of history, let's examine the various components of microcomputers and how they might be used. All microcomputers are made up of a central computing chip containing many circuits to carry out the main computing. Connected to this chip are memory chips of two kinds: (1) the permanent memory that cannot be altered and is always available when the machine is turned on--this memory is known as "read only memory" (ROM); (2) In addition to the ROM memory there is RAM memory--this memory is available to store information and is "randomly accessible memory" and disappears when the computer is turned off. Therefore, each time the computer is used, the program must either be loaded into the computer from disc or tape or typed from the keyboard. The main computer chip is also connected to a series of chips that can be used to save information on a tape recorder or disc drive. These are known as "input/output" (I/O) devices. Tape is a relatively inexpensive I/O device but is very slow because the programs are placed one after another on the tape, the program often desired is at the end of the tape (Murphy's first law of computers). While disc drives are more expensive, they are more reliable, much faster, and programs stored anywhere on the disc are quickly accessible. Less often microcomputers are connected to printers and telephone couplers to talk to other microcomputers. All the pieces of equipment used are called "hardware" and the programs that are used from tape and disc are called "software". With these basic understandings you can start to use a microcomputer and jargon words such as ROM, RAM, disc, and I/O, etc., rapidly become familiar vocabulary.

SPEAKING THE LANGUAGE

What kind of programs are useful for students learning with the microcomputer? Perhaps the most common use of microcomputers is in drill and practice. In this kind of program words and concepts are placed in a computer file and students use a quiz-like program to respond to questions. Depending upon the complexity of programming, the program may inform students how right or wrong they are. In more complex programs the students may be allowed several attempts, and if they do not succeed, the program may lead them through a tutorial routine to assist them in finding the right answer. Such programs can become very complex and are often used by teachers to keep track of a student's success in the use of vocabulary words and simple concepts. Such drill and practice materials can be made more interesting to students by using graphics. In such graphic programs, simple scientific concepts such as the distance and order of planets from the sun can be learned with greater understanding. In one such program, students are asked if they wish to travel by walking, running, traveling in a car, flying in a jet, or by traveling along a photon of light. The time taken to get to objects in the solar system is dramatically illustrated in such a program. While it deals with low-level learning, it nevertheless makes such learning more interesting and gives the learner greater opportunity to decide how the program will be used. The notion of user control is perhaps the most important point in the use of microcomputers. The early microcomputer programs that the 90 percent problem were primarily those programs that placed text and graphics on a microcomputer screen that allowed the learner to control only the rate of the page turning or how the length of time needed to study an illustration.

One of the rapidly increasing uses of microcomputers is in the realm of simulation. The microcomputer can be used to simulate anything from something as simple as a bouncing ball to a complex titration experiment. Biological simulations dealing with food web and population control provide very powerful higher order learning. Let's examine these simulations. As a first example, the following program accomplishes several purposes. It provides an idea of how a program written in the BASIC language works. It can be used to illustrate a simulation program and is a simulation of a sound of a bouncing ball. The program is simple, but the learning accomplished is quite real. First, the program.

```
10 HT=1000
20 FOR I=1 TO HT
30 NEXT I
40 PRINT "BEEP"
50 HT=.8 * HT
60 GOTO 20
```

Now a closer look at the program. The program is written in a computer language called BASIC. Basic stands for Beginners All-Purpose Symbolic Instruction Code. Program steps are entered as a series of line numbers; the lines could be 1,2,3, . . . 6, but units of 10 were selected in order that other lines could be squeezed in if needed. The first line (line 10) simulates the setting of the height of the bouncing ball at 1000. Line 20 starts the computer counting to itself for a time equivalent to whatever height the ball happens to be at that time; line 30 continues the counting. Line 40 causes the computer to make a noise (this will vary with different brands of computers). An Apple Computer "beep" is the control key pressed along with the G key. Other microcomputers have similar instructions for producing sound and should be followed. Line 50 changes the height of the bouncing ball to .8 of its present height. Thus, the coefficient of the bounce is 80 percent. Line 60 instructs the computer to go to line 20 and begin the counting again (a loop). This program of just 6 lines simulates quite well the sound of a ball bouncing. It also can be used as a basis for an inquiry lesson in science for students to understand simulation. For example, students can change line 50 to have a different coefficient of bouncing. One class decided to have the coefficient of the bounce change so that it would be greater than one. They found they had discovered "flubber," a substance that bounces higher each time rather than lower. What students generally detect first is that stimulation is not truly real. Any normal bouncing ball stops after a certain time, however, the simulated ball will go on forever (or until the teacher pulls the plug in desperation). Another class found if a line was added to the program to read

```
25 IF HT   1 THEN STOP
```

then the simulation is more realistic. Other classes modified the program to print a dot or number on the screen each time the ball bounced. Their computer did not have sound effects, but they could see the "bounce." They also discovered that they could count the number of times the ball bounced before stopping.

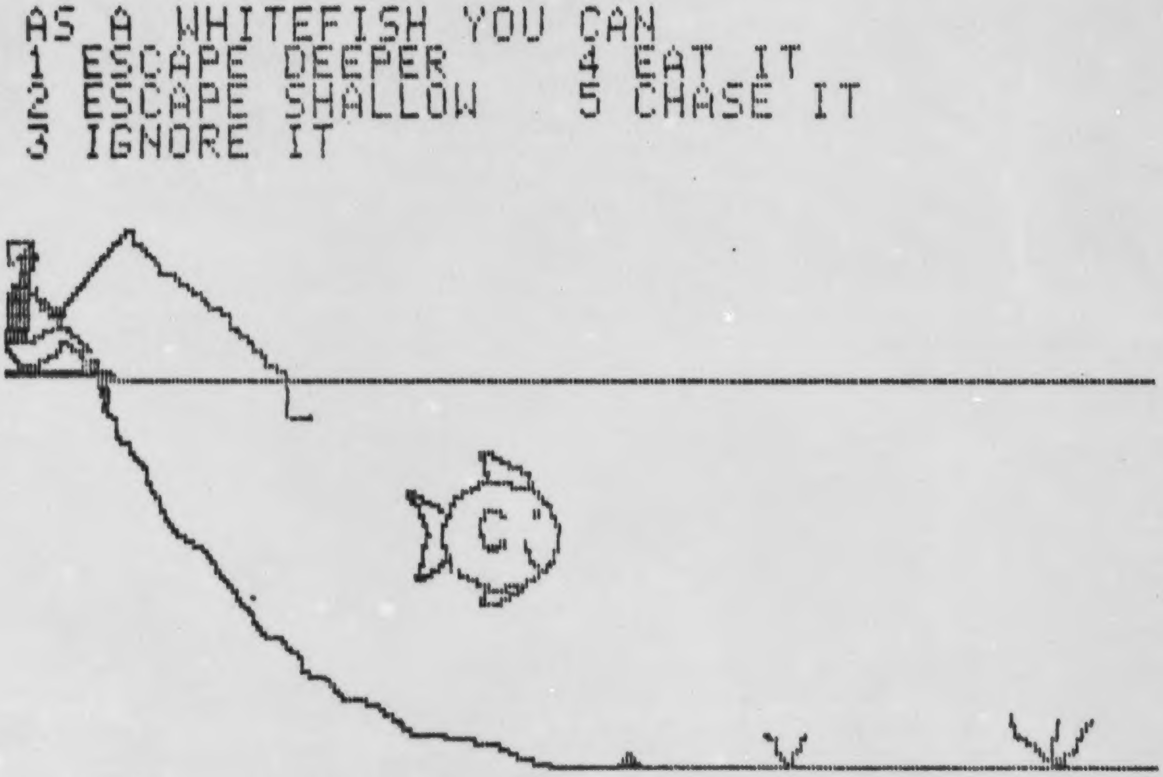
A simple program such as this can be used for higher level thinking skills concepts and allows students to perform true scientific experiments.

The next simulation program will illustrate how microcomputers may be used and also to show how they might be misused. This program is called "O'Dell Lake" and is available from the Minnesota Educational Computing Consortium (1980). In O'Dell Lake, the students take the role of a fish such as a mackinaw trout, chub, whitefish, salmon or Dolly Varden. Playing the role of a fish, students are presented with one of the other fish and given the choices of swimming deeper, swimming shallow, chasing the other fish, or attempting to eat it. Depending upon the prey/predator relationship, the fish, played by the student, is eaten, eats the other fish, chases the other fish or gets away successfully. The program contains excellent screen graphics as seen in Figure 1, and it provides a great deal of excitement as well as learning for the students.

Unfortunately, in many learning instances this is as far as the learning goes. Although the materials, supplied by MECC include excellent ancillary materials, they are not used by some teachers who are interested in "just showing a good program." Thus, what could be a good learning exercise to build an entire food web of O'Dell Lake turns out to be a fish eats fish experience.

Microcomputer programs can be excellent but they should provide the basis for learning experiences rather than being ends in themselves. Science teachers decry the teacher who enters the teacher's lounge on Friday and asks if anyone has a film. Unfortunately, just as easily, we could have the Friday afternoon microcomputer program club with just as disastrous results.

For upper level science classes, the microcomputer can be used to analyze data from experiments the students have done. Perhaps one of the best uses of a microcomputer is that of



```
AS A WHITEFISH YOU CAN
1 ESCAPE DEEPER     4 EAT IT
2 ESCAPE SHALLOW    5 CHASE IT
3 IGNORE IT
```

Figure 1. O'Dell Lake (Minnesota Educational Computing Consortium, 1980).

helping students to analyze data. The example below is a result of a series of experiments carried out by students with visual handicaps in the grades four through six. The experiment is from the "Science Activities for the Visually Impaired" (SAVI) at the Lawrence Hall of Science, Berkeley, California (1977). In this experiment, students place washers in the tub of a pan balance to find the amount of force needed to break the attraction of two magnets separated by spaces (See Figure 2).

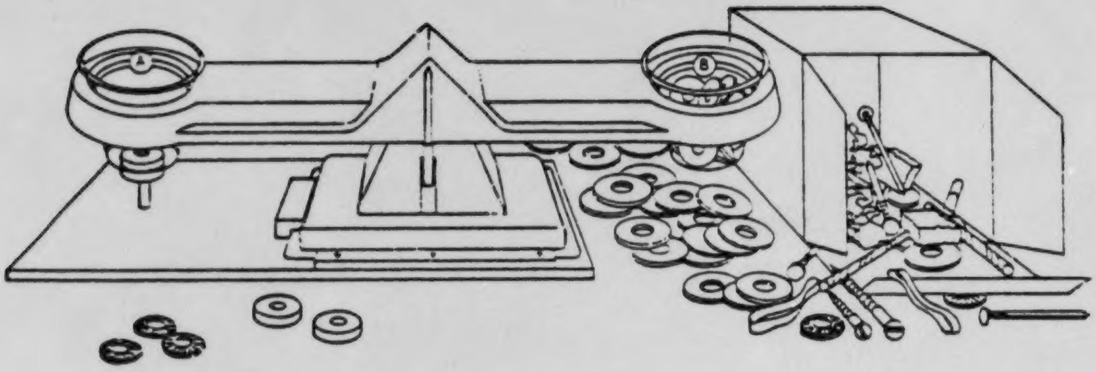
Not only were the developers and evaluators of the program interested in finding whether or not the students would be able to accomplish the experiment and produce reasonable data to allow them to infer results, but as an added bonus, they found that the students could use microcomputers to help them draw inferences from the data.

First, the data are entered as a graph as shown in Figure 3. Then, running a computer program that fits a line through the data (Figure 4), the students were able to use the fitted line to see that their data made sense and that predictions could be made from the graphical results.

Using the bright TV screen and large charts from a computer printer, students with limited sight could see the relationship of their own graphs compared to those drawn by the computer. For students in tomorrow's high school, using the computer to help analyze data will be as commonplace as using a pocket calculator today. Using the microcomputer to assist in graphing, curve fitting, and estimating the location of new data points, can be combined with simulation to help students achieve a thorough understanding of many concepts. While primarily useful for high school and college students, the following example will demonstrate the powerful use of new technology as both the tool and generator of concept development.

Titration is one of the most common experiments in junior high school and high school chemistry. Some of the basics of titration are found in many elementary school curricula. Using titration to find the concentration of one substance dissolved in an another substance is often done in the laboratory with beakers, solutions, titrates, and chemical indicators that change color when a particular concentration is reached. A challenging and useful experiment, titration offers some problems in the laboratory. The preparation of chemicals is time consuming and expensive. If a deep understanding of titration is desired, then students need to carry out many titrations. Time and the need for coordinated laboratory use then become critical factors in the understanding of such a concept.

In such a situation a good microcomputer simulation is most valuable. CAREFUL! The simulation should not be used to replace the real experiment. After the students have developed the necessary skills and have done the initial laboratory titration, the microcomputer simulation can help them develop the necessary



OVERVIEW

In *The Force*, the students explore permanent magnets. They find that some objects are attracted to magnets and others are not. The youngsters use the SAVI balance to measure the force of attraction between 2 magnets. Finally, the youngsters record the change in the force of attraction between 2 magnets as the space between the magnets increases.

BACKGROUND

A fisherman lost in the woods after dark must work his way carefully back to camp. He listens for familiar sounds, strains his eyes for flickers of light, and continually refers to his compass. He knows his camp is north, and if he follows his compass carefully, he will soon be safely in camp.

The fisherman's compass consists of a small magnetic bar mounted in such a way that it can pivot freely inside a case. The Earth is surrounded by a magnetic field which is strongest near the Earth's North and South Poles. The compass' magnetic bar and the Earth's magnetic field interact in such a way that the bar always points north and south, thus making the compass a valuable tool for determining direction. This is one important use for permanent magnets.

We tend to take magnets for granted because they are all around us. Refrigerator and cabinet doors utilize permanent magnets that keep them securely closed. Doorbells, toys, loudspeakers, and tape recorders all make use of magnets.

Figure 2. The Force (SAVI,1979).

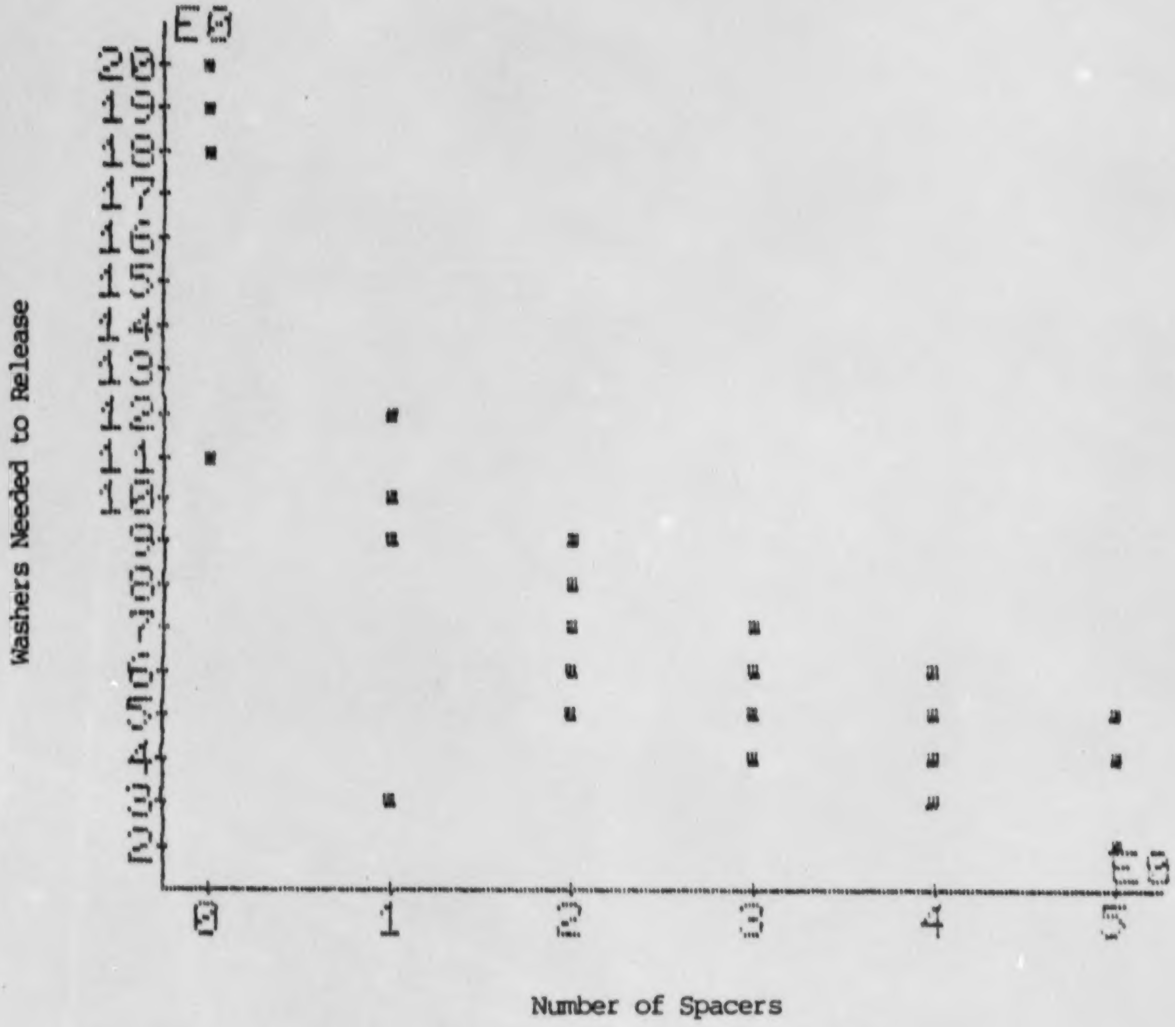


Figure 3. Number of Washers Needed to Cause Release of Magnets Separated By Spacers (University of Michigan, School of Education, 1981)

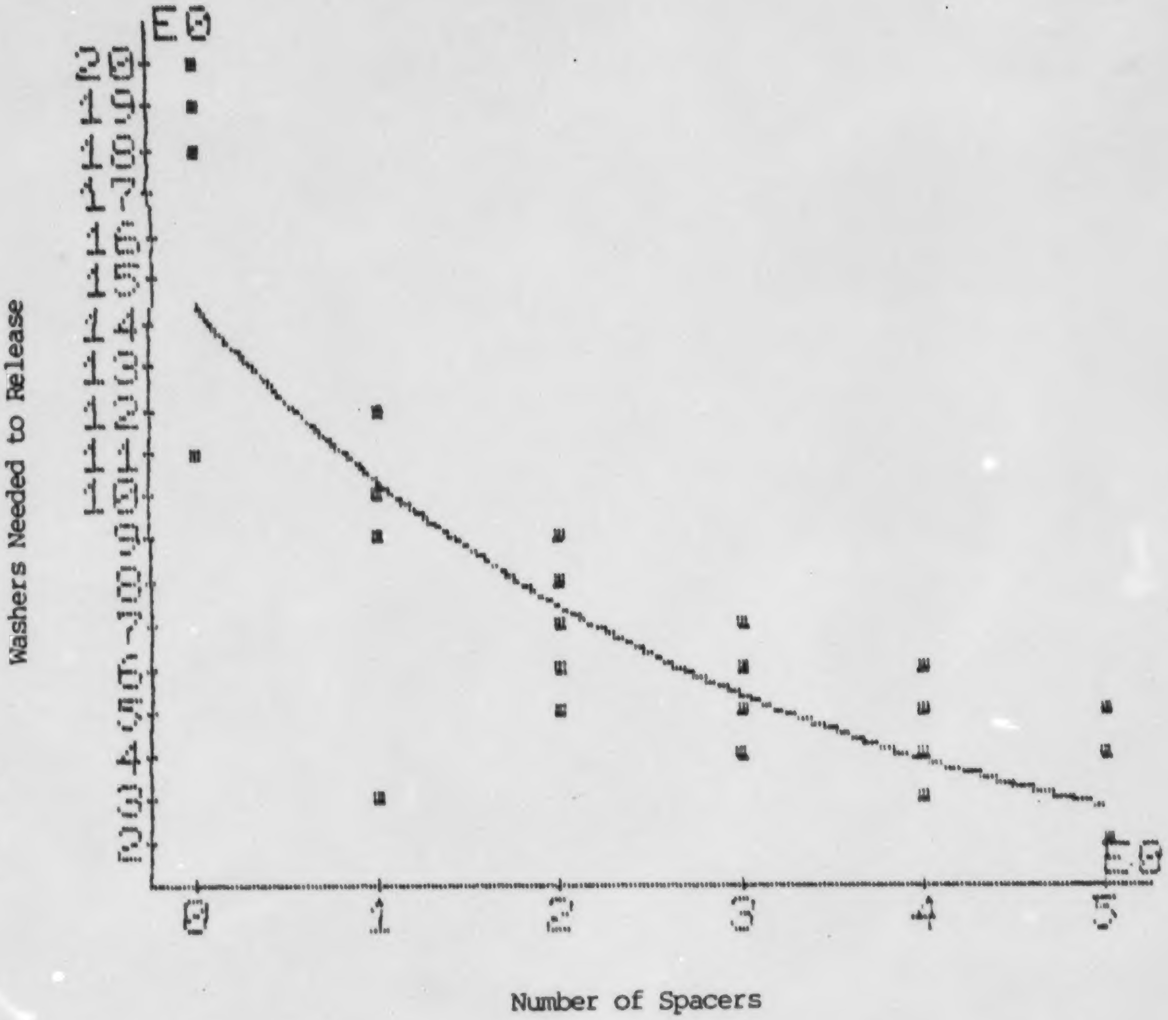


Figure 4. Number of Washers Needed to Cause Release of Magnets Separated By Spacers (University of Michigan, School of Education, 1981)

abstract understanding and, at the same time, provide a close learning relationship to the actual experiment that is lost even in the most carefully planned problem sets.

The elements of a program designed to bridge concrete and formal thinking are shown in the following paragraphs.

First you are presented with the following introduction

```
Apple Titration

You are to find the normality of an acid
 by neutralizing it with a base of known
 concentration.

Your buret holds 50 ml of base.

The unknown acid is less than
 .5 but more than .1 normal.

PRESS -RETURN- TO CONTINUE
```

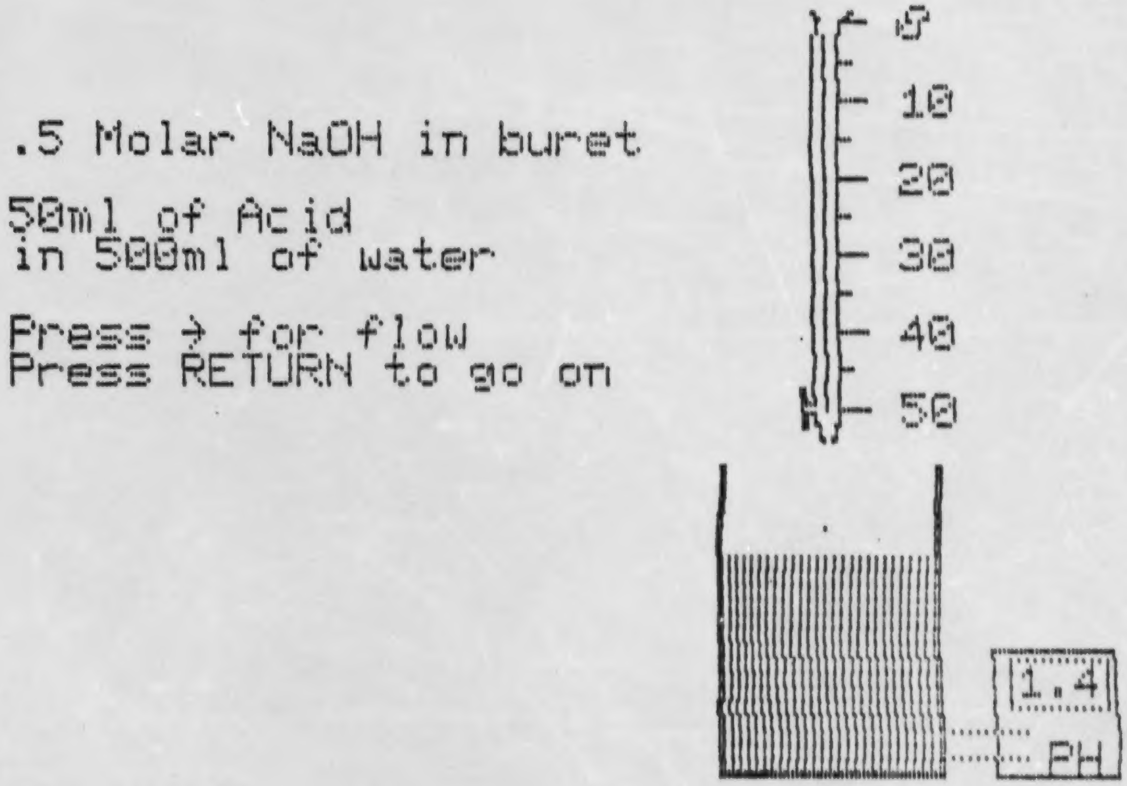
The next screen of information asks you to select the molarity of the base in the buret from choices of .1, .2, .4, and .5.

Then you are asked for the amount of acid (ml) you wish to have in the water in which the base solution in the buret will drip. As shown in Figure 5, the program presents a graphical illustration of the actual procedure and you can start and stop the process by pressing keys.

When the acid solution in the beaker changes color you are requested to enter the reading on the buret and then calculate the normality of acid in the beaker. Whew!! A complex problem but one that can be solved by students several times in the classroom rather than one time in the lab.

Notice that the problem allows students to determine the basic values needed in the problem. Even though it is a simulation, the student must carry out calculations and make most of the same decisions that are needed in an actual experiment. The real power in the simulation comes from the elimination of extraneous variables that often crop up in real experiments and provides for concentration on the more conceptual aspects of the problem.

Science teachers can learn from such a simulation. Simulations offer a bridge between concrete and abstract reasoning. Because programs can be made to stop for input you can pause, providing students time for reflection and calculation, attributes sometimes missing in an actual laboratory



.5 Molar NaOH in buret

50ml of Acid
in 500ml of water

Press → for flow
Press RETURN to go on

Figure 5. Apple Titration (University of Michigan, Department of Chemistry, 1979).

experience. The use of such a simulation has the value of providing the science teacher the opportunity to present each student with a different problem just by programming in a slightly random factor for one part of the problem. Such assistance for the science teacher provides us with the next major feature of the use of microcomputers.

A well designed overhead projector transparency, or any good laboratory instrument or device, are common tools of our profession, and, unfortunately, are responsible for the large science teaching budgets. The microcomputer can be an excellent tool, not only for students but also for teachers. Using the microcomputer to develop tests, helping to design experiments and demonstrations, and using the microcomputer as a word processor for providing assignments and reports (yes, even this chapter) are sophisticated applications that are fast becoming a powerful aid to the science teacher.

The microcomputer has been used as a means to help in the understanding of technological concerns in science teaching. Through the use of such technology comes understanding. Reading, discussing, and talking about technology are poor substitutes for actually using technology. Such use not only provides a deeper understanding of the technology but also provides insight into the limits of such technology. Just as a good simulation can help students focus on the concepts needed in a science experiment, it also lacks the hidden variables that provide for the frustration and, better yet, it can provide the unexpected discoveries that often move science ahead. Marie Curie (winner of two Nobel prizes) would never have discovered radioactivity if she used only a simulation! (Had she the use of present technology perhaps results of her experiments might not have been so disastrous for her.)

In an age sometimes referred to as "the information age" computers are rapidly becoming the most visible example. Thus, the selection of the computer as an example of technology was deliberate. The familiar but mysterious and unknown does characterize the vast array of computers in our environment. As with the gods of ancient Greece and Rome, will we become familiar with computers but not understand them and believe they have inordinate control of us? Or will our lives be enriched by the experiences that technology may bring? Will we temper the control we have of the devices and with such understanding and control solve some of the serious problems that face us with increasing frequency?

As science teachers we face an unusual task. We have, within our discipline, the responsibility to teach about technology. What better way to teach than to use the actual technology itself! Finally, the technological concerns we all have are real and must be addressed. We have the opportunity not only to help our students understand the problems of technology, but even more. Through simulation, program design, and working with the computers, students (and we) can understand the use, the advantages and disadvantages, the strengths and weaknesses of technology. Can we do less?

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CHAPTER 9

SCIENCE TEACHING AND ENVIRONMENTAL CONCERNS

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and

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Environmental education and elementary science teaching--what do they have in common? Both are on the endangered species list! Or, if you will, are rapidly approaching extinction! The standard, traditional remedies are: rationalize that science and environmental education, which can lend support to all aspects of the curriculum (i.e., language arts, social studies, mathematics, etc.), should be taught only at the junior and senior high school level; have an environmental concerns day in the spring to pick up litter on the playground; hang an ecology flag in the classroom; have students build a solar hot dog cooker for the science fair; draw pictures of pollution! Or, what may even be more of a problem, teach science as a reading course from the textbook, define and spell science and environmental words correctly, write sentences and stories about how we are "mucking" up the world, but choose to let it remain someone else's problem.

These remedies, while possessing a positive intent, fall extremely short in creating an effective elementary environmental science education program. In fact, the continued use of these approaches will promote a lack of awareness of the imminent environmental dangers facing the world today. A few of the possible scenarios for the future follow; they illustrate the consequences of this traditional approach to elementary science education.

Scenario I: Energy

> One day we wake up to find that our environment has not become extinct. But we have!
>
> What happened? "I was preparing my reading lesson plans and everything seemed to be OK. The next moment I am talking with the angels."
>
> Well, it seems that some small country I never heard of someplace on the earth had a major fuel/energy problem. No, not nuclear or oil or coal or natural gas.

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Firewood!

That's right. Firewood! The people needed fuel. No one really knew much about the problems of this small country and, could not have really cared less; no, we did care, I guess, but not enough to notice. So this small country with its military dictator decided to get the world's attention. He purchased the available "nuclear technology" to serve as a fuel source for his people from one of the major powers. However, when he obtained the knowledge necessary to serve as an energy source for his country, he also had the knowledge to develop nuclear weapons. He developed a nuclear bomb and fired it at a neighboring country to distract them while his armies looted firewood. The country being attacked then retaliated with their own nuclear warheads. The major powers jumped in to protect their "allies" and before long, the 50,000 nuclear bombs we have on the earth were put to their intended use, destroying and killing. And, they did a fantastic job--not a thing was left. Nothing survived. After all, if my country does not survive, yours is not going to survive either. So there!

Scenario II: Food

Or, one day we wake up to find the environment has not become extinct. But we have!

What happened? I was preparing my 40 drill and practice sheets in arithmetic for my youngsters and everything seemed OK outside. The next moment, I was talking with the fallen angels!

Well, it seems that the rice crop failed on a world-wide basis and starvation was imminent for billions of people. Of course my refrigerator was only half full, so I could sympathize with their plight. If these countries only had better farm policies, this crop failure would not have happened.

But the crop failure occurred in 65 countries. Could they all have had such bad farm policies? I am not a farmer and, besides, I have my "basics" or 3 Rs to teach my children. I asked one of the angels what happened? "Should we have sent some tractors to these countries? Or fertilizer?"

No. It seems that a blight attacked the rice crop and wiped it out.

Oh? So what? Plant a new crop and things will be OK.

Well, unfortunately there is no more rice seed to plant.

You have to be kidding!

Nope! You see, several years ago, companies were allowed to patent seeds. No one really paid any attention to that. So these seeds got better and better and before long, all the farmers in the world were using these patented seeds. And, since they were so good, the other seed manufacturers gradually were eliminated through good old competition. Finally, only one seed type for rice was left and 99 percent of the world used it. And, it was a great seed, producing abundant crops. That is, until the blight hit and killed the crop.

Gee, didn't something like that happen in Ireland in the 1800s?

Right on, good brother. Fortunately the world population was not depending only upon those potatoes for sustenance.

Sure wish that were true now!

Scenario III: Population

Or, one day, we wake up to find that the environment has not become extinct. But we have!

What happened? I was making up the new set of classroom rules for my children to keep them orderly, quiet, and paying close attention to what I would be "telling" them in class and everything seemed to be OK outside. The next moment I am reincarnated as a cricket on another planet. Chirp?

Well, it seems that the population of the earth grew and grew and grew. And finally there was not enough food and space in some countries for all the people. But we, in our country, were not over-populated and business went on as usual. In these other countries, though, they forgot that there are only two solutions to over-population. One is to control the number of births, the other is to "encourage" death. Since we did not control births, then death must be the answer. And, some countries began using their nuclear warheads to give their people a chance to have space and food.

> But those countries that had space and food did not really concern themselves with the problem. After all, they made their own bed so let them lie in it. But humans do not want to choose to die and will fight first. They did, others fought back, and the 50,000 nuclear warheads were put to their intended use.
>
> Holy cow! If I had known that, chirp, I would have sent them some of our shelved sex education materials that were banned several years ago. Chirp?

These are all bleak scenarios of the future. There are numerous other scenarios that are positive. They introduce a future where humankind prospers because our "world" concerns are seriously addressed. Obtained firewood, the effects of insect blight, and overpopulation are serious world problems today. We can let fate determine which scenario will occur. Or, we can act to choose the direction we want to move. Most individuals, given a choice, would hope to achieve positive scenarios for all citizens of "Island Earth," a "world perspective," if you will, which is essential today and will become critical in the future.

In an effort or attempt to achieve a "world perspective," we must introduce elementary school age children, as well as adolescents and adults, to science and environmental concerns. These world concerns and issues are immediately relevant to all of the earth's inhabitants. A concern- or issue-oriented curriculum, therefore, will make learning more meaningful, because it demonstrates the need to understand basic environmental and science concepts. Surely, nothing could be more "basic." Instead of moving back to the basics, let's move forward to them.

Traditionally, the model for the elementary school curriculum begins with self and family. It then moves to the neighborhood, to the community, region, state, nation, and, finally, the world. Conversely, a key distinction of the issue-oriented curriculum is that it begins with the world, and then moves to self and family. This view also requires a multidisciplinary focus that transcends traditional curricular boundaries. As an example, an issue-oriented curriculum would center on the effects of pollution, whereas a content-focused curriculum would only study pollution, as a principle in a science class, i.e., out of its broader, multidisciplinary context. Man, and schools, have broken the real world down into boxes called science, mathematics, English, etc. The issue of patented seeds, presented in an earlier scenario, is a science, health, mathematics, communication, and social studies problem. You cannot separate them if you want to examine the issue.

The developmental level of elementary school students demands that children have direct experiences in order to begin to understand a concept. A careful look at the curriculum of the lower elementary grades shows, however, that we ask youngsters to learn concepts they have not experienced. In the classroom, we introduce a fictitious family model and neighborhood outside the realm of immediate experience. By the same token, we introduce the concepts of community, state, and nation to students who may never have left their neighborhood. A common instructional mode is to use pictures and other visuals as a substitute for concrete experiences. These could also serve to introduce world views as well as local, state, and national views. As an example, if students were studying the family, they could also study families world-wide. Elementary school students must have a world view of science and environmental concerns for understanding larger issues introduced at the secondary school level and in later life.

The US and the world have entered a post-industrial era, often referred to as the communication era. Educators are preparing students to remain in the industrial era by introducing facts and concepts out of context, in separate disciplines. This is no longer environmentally or educationally sound. A more promising option, in keeping with the communication era, is to develop concern/issue oriented elementary school curricula which address the student's future.

A multidisciplinary eco-centric curriculum model and suggested activities will be presented to demonstrate how an issue oriented curriculum can become a vital part of the elementary school program. We believe that all educators have an obligation to include environmental concerns and issues in their curricular programs.

STATE OF THE ART (AND SCIENCE)

Although environmental education is a required part of the elementary curriculum in most states, recent surveys indicate that most teachers are not involved in an environmental educational program. UNESCO found that environmental education curricular programs in elementary schools were insufficient in number and scope to make environmental education a national preoccupation (Hungerford and Teyton, 1980, p. 19). Jankowski's (1978) study showed that 19 percent of the teachers surveyed did not devote any time to environmental conservation concepts, and that the average portion of time devoted to environmental concepts in the elementary classroom was only 4.1 percent. Andrew's (1980) study of New Hampshire schools and the Fletcher, et. al (1978) study in Tennessee showed a similar lack of priority for environmental education. However, Stoker (1979/80) published a study in *Environmental Views* that found, among other things, that

1. approximately 1/3 of the teachers surveyed were

aware of student wishes to have environmental education in the school curriculum.

2. environmental issues were more often introduced in social studies classes, not science.

3. only four percent (4%) of the teachers felt adequately trained in environmental education methods and philosophy and, fifty-two percent (52%) favored a compulsory course in environmental education in their pre-service program (p. 30).

The educators responding to the survey stated that, "many schools and teachers use lack of funds as an excuse to do nothing; and, the rigidity of the school system inhibits participating in 'creative or extraordinary' programs." In conclusion, however, the majority of educators concurred that environmental education should be a "fundamental curricular objective" (Stoker, 1979-80, p. 30-3). Other studies, too numerous to cite, report time and time again that teachers are concerned about the environment and believe it is a part of the school's responsibility to teach about environmental issues.

There may be many factors presented to justify the lack of participation in elementary environmental education programs, but the most recent mentioned is the pressure to "return to the basics," or, for some states, competency based education. The thought itself has grown to be comparable to our other American values, (i.e., the flag, apple pie, motherhood, prayer, etc.). However, very little attention is given to the fact that the basic skills students need for the 1980s and 1990s are far different than what was needed in the nuclear 40's, 50's and sixties. Many parents, politicians, and educators are convinced that we must return to the basics of the "good old days," which, translated, means, "We should have an educational program like I had when I was in school--look at me, I'm successful, therefore it must have been good."

In addition, because many educators have been made directly accountable for the learning of their students, as measured by standardized tests, what can be measured by those tests determines what we will emphasize in the curriculum. Even though we continue to give lip service to meeting the needs of students and to individualized learning, these same parents, politicians, and educators believe that all students are alike and, therefore, that their learning can be measured in like terms. Whether real or imagined, these pressures of accountability and the loss of federal and state support for educational programs have forced teachers to retreat. Teachers teach only what is to be tested and how to take the tests. The "basics" are ignored; environmental education and other issue-related areas have been shelved. For some communities and states the situation is so real, or ludicrous, whichever your point of view, that one cannot use the term environmental but rather the "safe," traditional term--conservation. The term "environment" is thought to represent placard-carrying, liberal extremists and reactionaries, which are certainly examples of the devils own work!

Science and environmental education leaders have also created and contributed to the education problems we are confronting. During the past 12 years, we have been in a web of semantics over environmental education and how to maintain territory. Environmental education serves to be defined as as outdoor education, nature study, ecology, conservation education, energy education, marine education, environmental studies, etc., or a collection of many terms and inferences which all fail to describe the overall nature of the concept. This multi-cholomization--"the art of slicing up our area(s) of expertise into even smaller and less comprehensive pieces, setting up elaborate systems of non-communication and fighting guerrilla action over bureaucratic turf or funds . . . " --has done very little to clarify the problem (Schafer, 1980, p6). And, because of these misunderstandings, the belief by the majority of educators is that environmental education is a course to be added to an already crowded and fragmented curriculum.

In-service education programs have been viewed as a way to improve this situation. However, if an in-service program is scheduled for teachers, it usually consists of a "one-shot," two-hour program at the end of the school day, dealing with an issue or program which is much too broad to be adequately covered in that length of time. The tendency of planning fragmented in-service programs has been criticized by Baden (1980) and Cleary (1976) as well as by many other researchers. Frequently, issues and programs presented in in-service sessions are regarded by teachers as unrealistic or irrelevant to the classroom. These teachers attend in-service sessions because it is required, but they do not often change their teaching behavior.

McLaughlin and Berman (1977) found that one-shot pre-implementation training programs are not effective, while the value of an ongoing, well-planned program has proved to far more effective. Wilson and Blum (1981) describe an in-service program for a school system in which a special theme (i.e., environmental education) was chosen and developed during the academic year. Initially the teachers were involved with an overview of the theme, then scheduled in-service programs were provided to support it. Teachers were asked to select and use the concepts and strategies learned--later observation revealed that the teachers were using the material in their classrooms. Such programs, while frequently successful in raising the environmental conscientiousness of the participants and often increasing the amount and quality of environmental education in the classroom, are usually conducted on a voluntary basis. They tend to reach only a small number of educators, who by virtue of their very presence in a workshop, indicate a pre-existing awareness of science and environmental educational needs.

As science and environmental educators, we need to reach the vast majority of teachers who have little interest in, or simply are not aware of, the needs and curricular programs in science, environmental education, and, for that matter, social studies. Many elementary school teachers consider these to be curricular "frills" or "not-so-important" subjects, since students are seldom evaluated on these areas of study in competency based programs. The National Leadership Conference on Environmental Education (Stapp, 1980) addressed the issues and problems in teacher inservice education, clearly recommending what needs to be achieved to provide better program for education.

A MULTIDISCIPLINARY MODEL

In an attempt to rescue environmental education from its multichotomization advocates and "back to basics" fanatics, more rational educators support the thesis that environmental education isn't a subject area on its own but rather a multidisciplinary construct. This approach has been suggested as a means of introducing environmental concepts into the curriculum. Environmental educators distinguish the multidisciplinary approach from the interdisciplinary approach in that it centers on infusing the existing curriculum with environmental concepts rather than creating a new curriculum component.

Environmental education is a process rather than a specific subject or discipline; it's an attitude--a new vehicle for traditional curricula. It should be multidisciplinary, introduce objective evidence for students to interpret an evaluate, and since one of the goals of education is to help students to learn without the teacher, this serves that purpose well. It should prepare future citizens who are aware of the interrelationships and interdependency between natural resources, energy issues, and our economy, and what has been referred to as the man-made environment. Its goals have been designed, developed, and stated in many ways. Rather simply, the goals for environmental education should be to

1. recognize human interdependency with everything (i.e., all life forms, air, water, natural resources, etc.);
2. develop a sense of responsibility to maintain our environment in a manner fit for life;
3. cultivate an appreciation of and respect for the environment--these attributes should develop through one's lifetime.

In lay terms (i.e., the venacular) the major concepts that should be introduced to students center on four "basic" ecological precepts:

1. There is no such thing as a "free lunch"--everything costs something.
2. Everything is going somewhere--change is inevitable.
3. "Nature" knows best--the best plan of action is what "nature" decides.
4. Everything is interrelated or connected--each living organism and natural resource is a piece in the wenvironmental puzzle and its removal prevents the entire picture from being observed.

Concrete or participatory, hands-on experiences are a vital component of any effective curricular program. Students need to be outside in the "real" classroom--whether it's in the school yard, in a park, local factory, or a community/governmental meeting which is discussing or legislating current issues. One's environment includes both natural and urban settings. Generally, the aforementioned goals and precepts can be easily introduced into the elementary grades where teachers have self-contained classrooms. There is an ample supply of resources available for teachers. They range from resource people who will visit classrooms to packaged programs designed to provide experiences and programs away from the traditional classroom setting. Libraries often have a resource-linkage service for those who have programs available and those who are in need. Civic groups, governmental agencies, and business/industry usually have numerous programs and resources they would gladly provide for all education settings. A variety of printed and audio-visual materials are available through university teacher education programs. Science and social study educators are usually fully aware of materials, etc., that are readily available for the asking. Nature centers, boy and girl scout programs, and parents can also provide excellent resources for teachers.

What should be the scope-and-sequence of an environmental education program whose purpose is to develop a knowledge base and a lasting environmental ethic or eco-centric awareness? Most curricular models discussed in texts and journals suggest that primary school children begin at the individual or "me" level, focusing on areas of study which are most relevant to the child--self, parents, and family. The model, generally spiral or funnel shaped, then moves onto a second level which includes the home, school and neighborhood, then to state, country, hemisphere, and world. Environmental education programs generally begin introducing environmental conditions, local or regional issues, and cultural factors after the fifth or sixth grade level. World, or biosphere, issues are usually last to be introduced--often by projecting or forecasting future "gloom and doom" scenarios. Figure 1 illustrates this model, which we have titled the ego-centric curricular model.

The rationale for this traditional model appears to be well thought through, moving from self or ego-centric awareness to world or eco-centric awareness and responsibility.

Figure 2, Eco-centric Curricular Model is simply an inversion of the previous model and, in our judgment, is far more appropriate for developing a multi-disciplinary, concern oriented curriculum.

Rather than to specifically identify program parameters by grade levels, it seems more logical to attempt to have students perceive themselves in relation to world, not self. It is a matter of "goodness of fit." An individual's growth toward achieving eco-centric responsibility is more apt to occur when students are educated to continuously participate in a curriculum which begins with world environmental conditions, cultural factors, and biospheric issues that are then "brought home" to the individual level.

The eco-centric curricular model for environmental education has two key differences when compared to the traditional ego-centric model. In addition to inverting the focus of the curriculum from world to self, each level of the eco-centric model is a concomitant process (Figure 2 depicts this with arrows pointing in both directions). We realize that a small child cannot fully comprehend environmental conditions, cultural factors and biospheric issues. However, when these are presented in the relative context of "self," students begin to develop an individual environmental perspective which focuses on how they "fit" with the world, not how the world should "fit" them.

Eco-centric responsibility should be a goal for all science and environmental programs. It is developmental by nature, it can be achieved only when students obtain a multidisciplinary, concern oriented knowledge base that allows them to understand their place in the world community, and how they, as individuals, effect change. Figure 2 represents an eco-centric model which will foster world stewardship, not individualism.

As a parallel to this approach, we should reconsider our curricular procedures for introducing the traditional "basics" in the elementary school program. Typically, teachers introduce reading, writing, and arithmetic because students need to know these "tools" before they can address science, social studies, etc. An eco-centric perspective would emphasize the need to introduce the "basics" simultaneously, i.e., teach all subject areas at the same time to demonstrate immediately to the child why reading, writing, and arithmetic are necessary "tools" to be learned. As an example, when a student confronts the problems of energy, food, or overpopulation in the world and sees its relevance in relation to him, he will be further motivated to

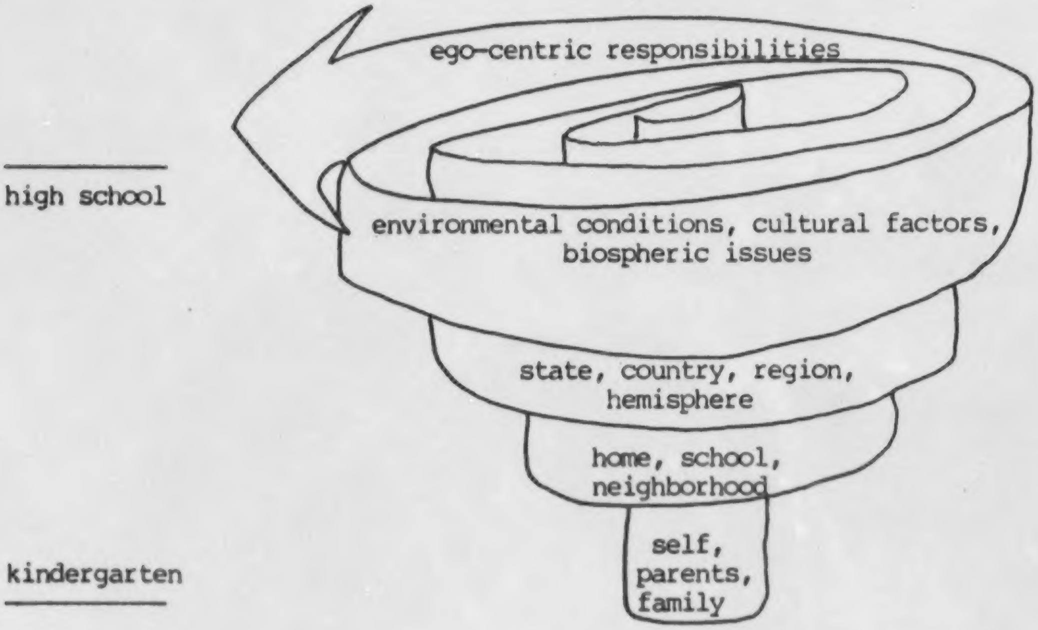
ego-centric responsibilities
high school
environmental conditions, cultural factors, biospheric issues
state, country, region, hemisphere
home, school, neighborhood
self, parents, family
kindergarten

Figure 1. Ego-centric Model of Curriculum

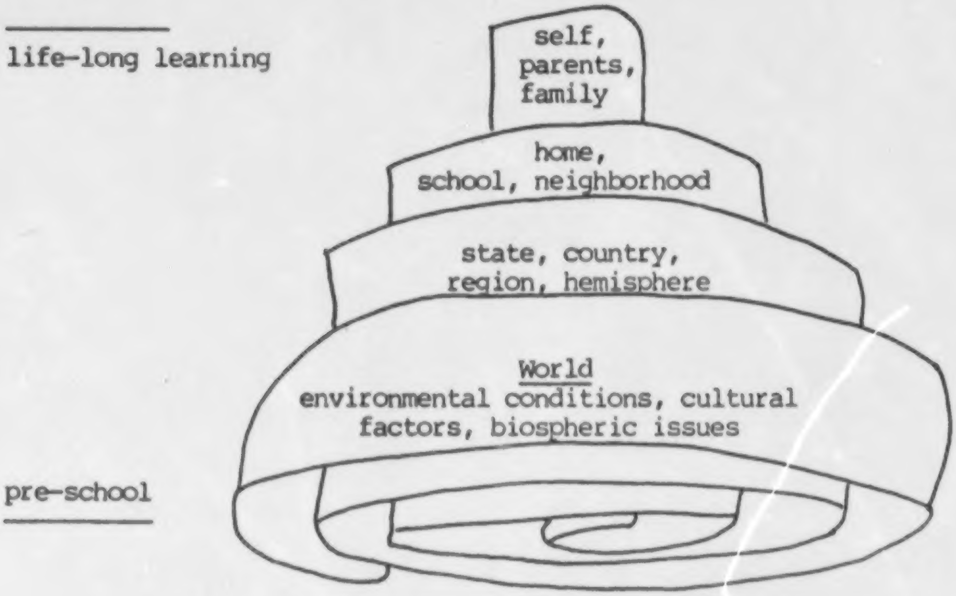
life-long learning
self, parents, family
home, school, neighborhood
state, country, region, hemisphere
World
environmental conditions, cultural factors, biospheric issues
pre-school

Figure 2. Eco-centric Curricular Model

pursue the "basics" in order to reach a personal understanding or solution.

Examples of multidisciplinary curricular programs which focus on the scenarios which were previously introduced (i.e., Scenario I: Energy; Scenario II: Food; and Scenario III; Overpopulation) are:

Scenario I: Energy

Energy, Earth, and Everyone, by Medard Gabel (1980) is a global and comprehensive assessment of more than 30 energy sources, their use, history, advantages, disadvantages, and production potentials with 39 world maps and over 125 charts and graphs. It is one of the most up-to-date, comprehensive energy documents available. It provides accurate data for developing additional exercises.

Scenario II: Food

Ho-ping: Food for Everyone, by Medard Gabel (1981) is an analysis of the earth's food situation from a global perspective. Existing food resources and production potential are examined in detail in 48 world maps and more than 150 charts, diagrams and illustrations. The findings are incorporated into strategies to ensure a nutritionally sound diet for everyone on earth. It is comprehensive and up-to-date, providing accurate data for developing additional exercises.

Scenario III: Population

Schultz and Coon (1979) have authored a text entitled, *Population Education Activities for the Classroom*. It is a collection of population education activities which cross traditional disciplinary boundaries. As the authors state, "It is the intent of this publication and its selected references to indicate that the new field of population education is process-education of a 'hands on' type, urging active involvment of the students in the learning process. This methodology

> more closely approximates the real-life immersion in which students will find themselves in terms of the population dilemma," (p. iv.). This text is easy to follow and is cross-referenced to concepts taught in mathematics, science, social studies, language arts, home economics, and art.

In addition, Buckmister Fuller (1980) has developed a World Game Map that incorporates these three issues into a single context.

ECO-CENTRIC RESPONSIBILITY IN TEACHING

Requiring or mandating what is to be taught in the schools is antithetical to the concept that the teacher is a professional who is prepared to make independent decisions about a given body of knowledge. Movements to require more and more content be taught give the professional educators less and less freedom to exercise their competence in the content selection process. As a result, instructional decisions become influenced more by the quantity of content to be taught than by the needs of the students. If we find that these professional teachers are not prepared to make these content decisions, then the remedy lies NOT in the creation of more mandates by outside authorities, but in a more intense and life-long approach to the teacher education program. Inherent within the concept of professionalism is the commitment to remain on the cutting edge of the fields of knowledge. If the teacher education program does not instill this commitment in its students, then it is useless to expect its practitioners to be any more than technicians who serve the mandators and not their students or clients.

The beginning of this chapter presented three scenarios based upon the assumption that the teacher is an instructional leader rather than a curriculum specialist. The following section demonstrates what can occur if the teacher is treated as a professional educator. The eco-centric model for environmental education presents a breath of fresh air by speaking to the professional teacher and not to the technician-teacher.

What is encouraging about this approach for the elementary student is its eco-centric rather than ego-centric core. Teachers who possess an eco-centric value system will include environmental concerns in their curricular programs. A passage from an exciting book, entitled Ecotopia Emerging, by Ernest Callenbach, (1981) will provide an opportunity to evaluate our own individual eco-centric awareness.

> Toward the end of the seventies about a thousand new chemicals per year were being introduced into the environment . . . of which almost 35,000 were officially classified as known or potential hazards to human health . . . . The federal government had begun a program of testing these substances to determine how

> severe were the dangers they posed. But it was estimated that, at the budget allotted, this testing program would not catch up for a hundred years--if then.
>
> Meanwhile, pesticides were being impregnated into upholstery and carpets and building materials . . . . Pesticides and herbicides were sprayed in parks and public buildings and buses and on gardens and golf courses . . . .
>
> Researchers hoping to find a viral cause for cancer were reluctantly driven to the conclusion that, though some virus process might be involved, the precipitating causes of cancer were something like 80 percent environmental. People were doing it to themselves. But this was not a message that most Americans were then prepared to hear; it went largely unreported and undiscussed, and the cancer rates continued rising. Chemistry graduates continued to receive lucrative job offers before they even stepped off campus. People went on breathing air that was known to be dangerous to their health, drinking water known to be contaminated, eating pesticide- and addative-laden foods, and concentrating their attention on making money in order (as they imagine it) to survive (pp. 17-18).

How did this passage make you feel? Depressed? Frightened? Angry? If you feel angry or maybe have a sense of frustration, then you probably have an eco-centric awareness that would lead to incorporating environmental concerns, such as those illustrated by Callenbach in the above passage, into your curriculum.

Today, there is a growing number of persons in a myriad of occupations who realize the necessity for humankind to rejoin the world environmental community. For too long ego-centric awareness has resigned supreme--for too long we have mistreated our island earth, serving the whims of people who are busily engaged in satisfying their ego needs. This awareness and corresponding value system has been perpetuated in the culture by our educational systems; it is time for concerned educators to implement an eco-centric value orientation into curricular programs. This is a very value-laden position. The degree to which you agree or disagree is a measure of you.

As a further example, the following principles or political actions center on an eco-centric value system. Three were previously introduced as scenarios, however, it is important that you develop your own position. An eco-centric perspective would support the following statements:

1. There will be no further extinction of any living species.

2. There will be an end to nuclear weapons.

3. There will be no manufacturing of carcinogenic (cancer causing) or mutagenic (mutation causing) substances.

4. There will be no growth in world human population.

5. There will be no arbitrary divisions of the land because of political boundaries when faced with environmental threats (i.e., acid rain produced in the U. S. crossing into Canada relieves the U. S. of its responsibility).

6. There will be an end of that aspect of the human competitive ethic which creates situations of starvation and senseless violence. (i.e., American farmers plowing under their wheat crop when 2/3 of the world goes hungry).

7. There will be an end of that aspect of the human competitive ethic which promotes situations of waste and senseless duplication of efforts which require high expenditures of energy (i.e., having extra-cost options on automobiles such as automatic windows, seat adjustments, and antennae or having move than 200 brands of breakfast cereal).

8. There will be no private automobiles that use energy or exude pollutants above the most efficient world-wide technology.

9. There will be no further wasteful erosion or destruction of marshland, forest, mountain, or desert ecosystems.

10. There will be no further ecological harm to the oceans.

11. There will be no impediments to the development of solar and passive energy technologies.

SUMMARY

Where do you stand? What do you believe is your major responsibility as an educator? Maintaining a belief system such as the one inherent in the above principles requires re-education. We were brought up in a culture which fostered a far different set of principles. This culture was transmitted by the schools and society. It goes without saying, however, that a new system is now appropriate, given the current environmental climate we have created and inhabit.

To conclude, the willingness to be re-educated is the critical distinction between being a professional educator or a technician. Your willingness is the criterion which determines whether you will examine the eco-centric curricular model. The earth not only requests, but demands, that it be treated with love and dignity. Without this commitment, there will no doubt be a time in the near future when the students in our elementary school classrooms take leadership roles in a society which more resembles Dante's Inferno than any image we have of the Garden of Eden.

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CHAPTER 10

SCIENCE TEACHING AND ENERGY CONCERNS

Walter L. Purdy

and

Robert Bernoff

OVERVIEW

The goals of the elementary school curriculum within the context of science instruction must reflect the present as well as the future needs of an energy-informed citizenry. The science curriculum today includes not only concept development but emphasis on skills necessary to live in our changing society. Beyond this, instructional objectives stress student understanding of the need for wise use of energy and the ability of students to discuss the views of competing interests prerequisite to making calculated choices among energy options for domestic and international needs. An ideal curriculum design that incorporates these objectives will ensure energy literacy for all students. The strategy of infusion and the use of interdisciplinary approaches for energy education has been applauded by educators and recommended for any new programs for energy education (NCSS, 1981). Successful infusion programs produce informed students who act as change agents within their families and communities and who are prepared to assume their roles as policy makers in the coming decades.

IMPORTANCE OF ENERGY EDUCATION

Although great changes have been brought about through the efforts of science teachers and others, there is a need for a greater sense of urgency in expanding energy education in elementary schools. World citizens living in the 1980s need energy-based science education as the framework for their awareness of the role of energy in society today and in the future. One demonstration of this growing public awareness was the theme for the 1982 World's Fair--Energy Turns the World. This theme set the tone for international cooperation in the development of exhibits and pavilions. According to Lawrence (1982) this event was a reaffirmation of the belief that citizens have the ability to influence their future, given the right tools and the knowledge to use those tools. For those who visited the World's Fair it was a picture of the present as well as a glimpse into the future.

Energy decisions that are made daily affect the future course of life on this planet. Students in our kindergarten classrooms today will be graduating from college in the year 2000. Their science instruction from their earliest years must prepare them for their responsibilities in the 21st century. This preparation must include opportunities to develop skills necessary for social decision making in a future of alternative energy sources. As citizens of the world, students must also be ready to address international energy issues. All the resources of the school and community must be utilized to ensure energy literate citizens. Recent efforts to develop cooperative plans between business and the schools have expanded the energy studies beyond the chapters of a science or social studies textbook. Resource persons from business and those engaged in energy related careers provide role models for students and place the content of the textbook into the context of life situations. Science teachers realize that the knowledge base is expanding so rapidly that the text can no longer be the sole source of information for students. The community must become the expanded classroom, the new encyclopedia of energy education for the 1980s and 1990s. In the search for innovative ways to improve and enrich the energy curriculum, educators must utilize the material and human resources available from industry, business, government, and other organizations interested in energy.

CURRENT ENERGY LITERACY

Energy education is not new to science teachers. World events, current data on fossil fuel depletion, and the understanding of the environmental cost of energy use and production have alerted teachers to the need for holistic instruction that identifies interrelationships and relates concepts and developments to world events. In 1978, an opinion poll distributed by the U. S. Department of Energy revealed that 65 percent of the adults surveyed did not consider the energy problem to be serious (Education Commission of the States, 1978). This lack of awareness alarmed science educators and provoked renewed interest in discussions regarding the goals of a quality energy curriculum.

There is a common agreement among educators that the goal of any energy program is to develop energy-literate citizens. Such a person demonstrates the following characteristics, as adopted from a conceptual framework for energy education (K-12).

- Understands that we can't make energy.
- Finds more efficient ways to use energy at home, at school, on the job, for example through the use of waste heat.

- Has some historical perspective on energy use and extraction; for example, has an informed notion of where we stand on the fossil fuel depletion curve.
- Compares life-cycle costs in deciding on major purchases.
- Invests to save energy, for example by purchasing home insulation when it is cost-effective.
- Knows how much energy is consumed in his/her household and where it goes.
- Is aware of the major sources of the energy used in his or her immediate job and in the economy as a whole.
- Understands that all energy use and production has a cost including an environmental cost.
- Can trace energy flows and thinks in terms of energy systems not just individual components.
- Tries to match energy-quality to energy use.
- Is aware of his/her home's orientation to sun and wind, and uses this knowledge to advantage.
- Supports long-term national efforts to improve energy efficiency.
- Understands a variety of ways of reducing energy use in personal transportation.
- Understands how active and passive solar heating work.
- Understands how refrigerators, air conditioners and heat pumps work; uses them efficiently.
- Keeps learning about energy (U.S. Department of Energy, 1982, p. 7).

A BRIEF ENERGY HISTORY

One way of gaining perspective on our current energy situation is to look back at our energy past. Here is a brief history of energy use in the United States based on Weaver's (1981) presentation.

1776 to 1885	Wood is America's main source of energy
1859	First oil well at Titusville, PA
1879	Electric street lights first used in New York
1885 - 1950	Coal is America's main source of energy
1950 - 1980	Oil is America's main source of energy
1957	America's first commerical nuclear powered electrical generating plant comes on line
1970	U. S. oil production peaks
1973	U. S. natural gas production peaks
1973	OPEC oil embargo and lines at gas stations
1973 to date	Energy prices increase and Americans become aware of present and future energy problems

In 1778, two hundred years ago, our energy came from roughly equal amounts of coal and wood. In 1981 energy used in the United States came from the following sources: oil--43 percent, natural gas--27 percent, coal--22 percent, hydroelectric--4 percent, nuclear--4 percent.

What will our energy sources be in 2080? We cannot be sure, however, we can reasonably assume that energy will continue to be a very important issue in the lives of the students now in our schools. The energy future need not be a frightening one. A historical perspective helps us to realize that our principal energy resources have been changing and will continue to change. With research, conservation, and careful planning this change need not be disruptive.

STATUS IN SCHOOLS

Each year through in-service programs, media events, and publications, more and more teachers are becoming interested in energy education. They look to other enthusiastic administrators and teachers who have cooperated to launch thousands of successful energy projects in elementary schools across the country. High school programs seem to receive greater press coverage. However, there are many examples of success stories in elementary classrooms.

One yearly event that provides impetus for all grade levels to develop energy consciousness is National Energy Education Day (NEED). Although this is a one day event by presidential proclamation, the celebration is extended by creative teachers throughout the course of the school year. Weeks of planning, study, and research prepare students and community members for the activities. Elementary school students participate in assembly programs, poster contests, time capsule burial ceremonies, energy watches, and numerous other activities to mark the event. Successful projects elicit the support of museums, local businesses and parents in scheduling activities. Other support and awareness follows from public radio service announcements, local television and newspaper coverage, and student exhibits in public areas such as shopping malls. The theme for NEED '83 encompasses the breadth of the event: Energy Economics--The Global, National and Local Connections (Katz, 1982).

Science supervisors have included elementary schools in numerous projects funded by foundations and state programs. The Franklin Public Schools' Project Feet is typical of a program for community involvement. Funded by the Executive Office of Energy Resource of Massachusetts, the project highlighted opportunities for students to visit museums and to tour the Seabrook Nuclear Power Plant Education Center. Students interacted with persons in energy related careers and with those who provide services to energy producers and users. Applications of classroom learning were made possible by problem solving sessions at various community sites.

One comprehensive program that has influenced energy education in its ten year history is Energy & Man's Environment (EME). This non-profit energy literacy organization provides continuing in-service training for teachers and administrators, with hands-on experiences in the construction of energy learning centers and games that are adaptable to all disciplines. Resources include instructional materials and "Quick Energy Lessons for Substitute Teachers." In the 1980-81 school year, more than 69,000 teachers and administrators participated in EME programs co-sponsored by businesses, industries and state government offices in cooperation with local school districts.

The National Science Teachers Association (NSTA) has contributed significantly to the enrichment of energy education through publications, conferences, collaborative ventures, and membership services. In the most recent joint effort with the Council of State Science Supervisors (CSSS), NSTA will identify and recognize science programs of excellence, including outstanding energy education programs. After an intensive search and rigorous evaluation process, the Search for Excellence in Science Education (SESE) project will announce the programs that are the most outstanding in the nation. This announcement will be a milestone in the movement toward defining excellence in energy education. Within the next few years it is hoped that these programs will be included in the National Diffusion Network.

FUTURE PROJECTS AND COURSES OF ACTION

As energy education assumes its rightful place in the elementary classroom in every district in the country, educators will view the school as an energy education laboratory. Using successful programs as models, students will not only read and discuss important concepts, but will have opportunities to apply knowledge to real problems. To facilitate this type of learning environment, the entire school can be represented. If this takes place, it will not be unusual to find regularly scheduled audits being conducted not only by the building engineer but also by administrators, teachers, community persons, and students. Creating a program for energy management makes it possible for youths and adults to interact on an equal basis to solve problems of common interest. Again, students can be introduced to career opportunities in energy related fields as a part of this program (Lewis, 1981).

Educators must continue to have a forum to continue the networking activities that have enriched energy education. Despite discontinued federal support, in-service education must be a priority for energy educators. Cooperative ventures between universities, school districts, teacher centers, and businesses can assist teachers in their efforts to be informed about trends and models of excellence in energy education. National Conferences like "Energy Education for the 80s" co-sponsored by the National Council for the Social Studies (NCSS) and the National Science Teachers Association (NSTA) bring together national leaders in energy education. These two major organizations called upon business and industry to help them plan this major event. This conference is one more effort on the part of NSTA and NCSS to address the problem of energy illiteracy described earlier in this paper. This conference and others scheduled by the local school districts provide concentrated in-service for elementary teachers. Exciting projects are being initiated each month as a result of collaborative planning between educators and business and industry.

WHAT SHOULD BE TAUGHT?

Faced with a limited number of instructional hours, teachers must make decisions about what should be taught. We have tried to make a case about the importance of including energy education in the curriculum of all elementary schools. But what topics within the general area of energy education should be emphasized? To help teachers make this decision we have developed a "conceptual map" of key energy topics. In order to clarify the meaning of each of the topics listed in the conceptual map, what follows is a brief paragraph describing each topic heading (see Figure 1 for concept map).

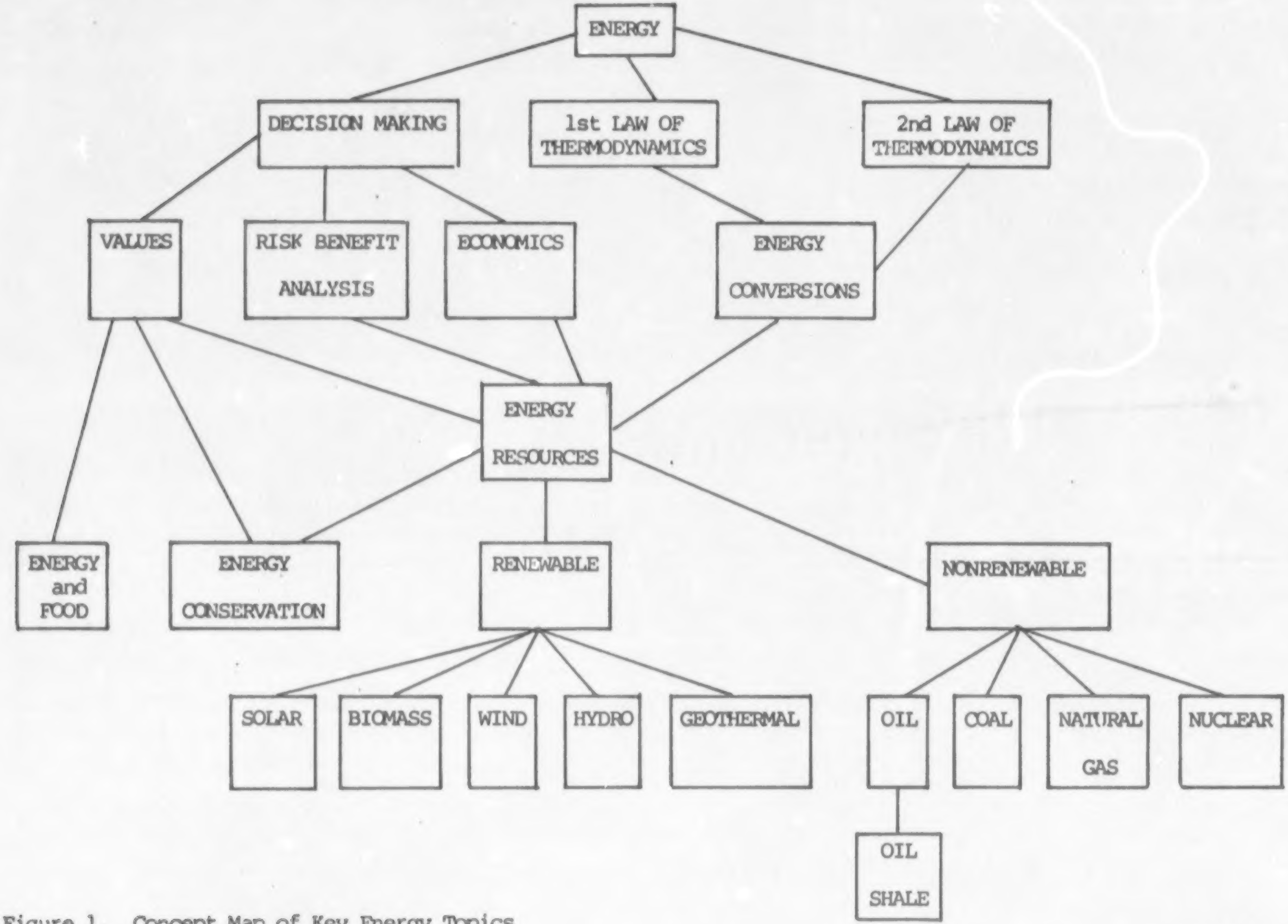

ENERGY
DECISION MAKING
1st LAW OF THERMODYNAMICS
2nd LAW OF THERMODYNAMICS
VALUES
RISK BENEFIT ANALYSIS
ECONOMICS
ENERGY CONVERSIONS
ENERGY RESOURCES
ENERGY and FOOD
ENERGY CONSERVATION
RENEWABLE
NONRENEWABLE
SOLAR
BIOMASS
WIND
HYDRO
GEOTHERMAL
OIL
COAL
NATURAL GAS
NUCLEAR
OIL SHALE

Figure 1. Concept Map of Key Energy Topics

Energy

Energy is a nebulous thing, an abstract concept difficult to picture, especially for an elementary school child. A moving car has energy, but so does a battery or a lump of coal. We generally picture energy in one of two forms. Kinetic energy is energy in motion--the bouncing ball, the wind, or waves. Potential energy is stored energy whether it be the water in a high dam or the gasoline in the tank. John Fowler summarizes the concept in the Energy-Education Source Book:

> Whenever we have heat, or light (or the other forms of radiation: radio, x-ray, ultraviolet, etc.), or motion, we have energy in action. Whenever we have something that can ultimately provide us with heat, light or motion, we know that energy is stored in that something (Fowler, 1975 p. 103).

The First Law of Thermodynamics

One of the basic principles of science, this law is also called the Law of Conservation of Energy. It states, quite simply, that "Energy can neither be created nor destroyed." This law emphasizes that energy is constantly changing from one form to another. Energy from the sun is stored in a growing plant, eating the plant can convert this energy into the movement of human muscles, which can then convert it into the motion of a hammer whose friction with a nail converts the energy into heat. This law seems to indicate that we should never have any problems with energy supply since energy is never destroyed. But the supply problems are with useful energy, a concept made clearer by the Second Law of Thermodynamics.

The Second Law of Thermodynamics

There are many ways of stating the Second Law of Thermodynamics. For our purposes it is probably best stated, "In any conversion of energy from one form to another, some of the energy becomes unavailable for further use." This is because in each of the conversions some of the energy ends up as heat which cannot all be converted back into another form. The energy stored in the gasoline in an automobile tank is converted by the engine into the motion of the car. Some of the energy is not usable because of friction in the engine, of the tires with the road, of the wind over the auto body, and in the braking system. All of the energy from the gasoline ultimately ends up as heat. This heat leaks into the environment. We are unable to convert this "lost" heat back into gasoline. This heat energy heats up our surroundings. It is no longer available to us for useful purposes. The second law, sometimes called the heat tax, is the scientific principle which explains our potential problems with available sources.

Energy Conversions

Most of our concerns are not with energy per se; they are with energy conversion. Man's advancement has been tied to developing efficient means for energy conversion: the cave man's use of fire to cook meat and provide warmth from the stored energy in the wood, sailing ships using wind energy, all sorts of modern conveniences powered by electricity converted from the energy in coal, oil, natural gas, moving water, or nuclear fuels.

Energy Resources

When we speak of energy resources we usually mean some form of stored (potential) energy which we can convert to a usable form. Some common energy resources are wood, coal, oil, natural gas, uranimum, geothermal wells, and dammed rivers. The current intense interest in energy resources comes from the growing awareness that many of these forms of stored energy are becoming scarcer and more expensive and that we must learn to conserve these resources and develop new ones.

Non-Renewable Energy Resources

Non-renewable energy resources are those which have taken eons of time to form. These resources usually exist as deposits under the earth, and they are finite. That is, only a limited amount of each of these resources exists and once that amount is used up that resource is gone forever. The most common non-renewable energy resources are the fossil fuels (i.e., coal, oil, and natural gas) and the nuclear fuels, such as uranium.

Oil

Oil or petroleum is a flammable viscous liquid that frequently occurs in pockets trapped in the upper strata of the earth's crust. Oil is a complex mixture of various chemical compounds called hydrocarbons because they are made of hydrogen and carbon. When oil is refined it is broken down into a number of fractions such as heating oil, gasoline, and kerosene. The various oil components are used as fuels and as the raw materials to produce plastics, fertilizers, and many industrial chemicals.

Oil is a fossil fuel believed to have formed from the decomposition of buried remains of prehistoric animals. No one knows for sure how much oil remains under the earth's crust. However, most experts agree that, depending on the rate of usage, the world's oil reserves will last for about 50 to 100 years.

Oil Shale

Oil shale is a rock which contains hydrocarbon materials. When oil shale is heated to high temperatures, oil is driven out of the rock and can be recovered. At the present time it is much more costly to get oil from oil shale than it is to get oil from liquid oil deposits.

Coal

Coal is a combustible solid organic material which is about three-quarters carbon. Coal is a fossil fuel formed by the decomposition of buried plant material under intense pressure for centuries. Most coal deposits contain impurities which can cause air pollution when they are burned. These impurities can be removed before the coal is burned or from the exhaust gases which result from the combustion; however, this adds to the cost of the coal as a fuel. The world's reserves of coal are estimated to last for several hundred years.

Natural Gases

Natural gas is a gaseous fossil fuel which consists mostly of methane (CH_4) and small amounts of other hydrocarbons. Natural gas is found in porous rock formations under the earth and often in association with oil deposits. The world's resources of natural gas are also finite and estimates are that they will last for about 50 to 100 years.

Nuclear Fuels

Nuclear fuels supply the energy resource for the operation of nuclear reactors which produce electricity. In the U. S. in 1980 nuclear fuels were used to produce about 10 percent of the electricity generated in the United States. The main nuclear fuel is uranium occurring in deposits which must be mined. The isotope uranium 235 is then concentrated so that it can be used in a nuclear reactor. The amount of uranium 235 available is finite and estimates of the amount of this resource are in the 100-year range. However, breeder reactors, of the type now in use in other countries, can produce useful nuclear fuel from the more common uranium isotopes. Using breeder reactors expands the world's reserves of nuclear fuel to thousands of years.

The use of nuclear reactors is still a controversial issue in the U.S. and in many foreign countries.

Renewable Energy Resources

Renewable energy resources are those which are constantly being formed. These sources, such as solar and geothermal power, will continue to be available as long as the sun and the earth exist.

Solar

Solar energy generally refers to the electromagnetic radiation transmitted by the sun. Although the sun sends huge amounts of energy to the earth each day, this energy is very diffuse and it must be concentrated in some manner in order to be useful. With the exception of nuclear energy resources, almost all other forms of energy are traceable back to the sun as their original source. For example, the hydroelectric power generated by falling water comes from the energy of the sun, which evaporated the water raising it to the higher levels from which it falls. However, the term solar energy resources usually refers to direct use of the sun's rays. Flat plate solar collectors, often placed on roof tops, can be used to heat water. Well designed homes in appropriate locations can use the sun's energy for space heating. Photovoltaic or solar cells convert the sun's energy directly into electricity. Systems of movable mirrors can focus the sun's rays and boil water for steam generators. There is a great deal of research world-wide attempting to develop efficient ways of using the sun's energy. By the year 2000 the United States hopes to use solar energy to supply 20 percent of our needs.

Biomass

Biomass refers to energy resources resulting from growing plants. Biomass is actually another solar energy source. The sun's energy is stored in growing plants by the process of photosynthesis. The result may be trees utilized as firewood or plants that can be converted to alcohol by fermentation.

Wind

One of man's earliest uses of solar energy was to harness the wind to drive sailboats or to turn mills used for pumping water. Modern windmills can be used as efficient electrical generators. Large wind generators for use in areas with steady winds are currently under design and being tested in several countries.

Hydropower

Hydropower refers to power produced by falling water. In the United States, hydroelectric stations produce about 10 percent of our electrical energy. A hydroelectric plant consists of an electric power station which uses the energy of falling water to turn a turbine which generates electricity. The construction of hydroelectric stations usually requires building dams and careful consideration of the ecological effects of damming rivers.

Geothermal Energy

Geothermal energy refers to the heat energy in the earth's crust. By drilling wells in appropriate regions it is possible to tap hot springs and use hot water to heat houses or geothermal steam to produce electricity in steam turbines. Half of the electricity used in San Francisco comes from a geothermal electrical station, The Geysers.

Decision Making

Paralleling the need for facts concerning energy and energy sources is a need to develop the ability to make reasonable decisions regarding energy problems and energy resources. The decisions regarding whether we should pursue research on tar sands, develop new nuclear power plants, or build more dams require that we have an energy-literate public. We must develop adults who can weigh potential benefits and risks and come to reasonable conclusions.

Values

Values are the qualities or principles which one holds as being important. Once one knows the technical facts one often finds that the ultimate energy decisions are based upon one's values. If a dam may result in the extinction of a rare species of water animal should the dam be built? How does one reach such a decision? Which is more important, people's energy needs or the extinction of a species? These are value decisions. We must all learn to recognize when a decision depends on values and to be clear about what our own values really are.

Risk Benefit Analysis

Traffic accidents are a major cause of death in the United States. Should we ban automobiles? Lead in gasoline causes air pollution and detrimental effects in our environment. Should we ban the use of lead-containing fuels when lead-free fuels with similar octane ratings are more expensive? These are risk benefit decisions; they depend on our values and on our analysis of whether the risk taken is worth the benefit. Often intelligent decisions depend on the ability to weigh potential risks and potential benefits. It is important for students to learn about and understand the process of risk benefit analysis.

Economics

In our society many of the decisions regarding energy are economic decisions. Increases in the cost of gasoline and other fuels have influenced our choices of automobiles and life styles. Homeowners make decisions about which fuels to use and what conservation methods to employ based upon costs. If insulating one's attic will have a payback time of five years (that is, the cost of the insulation will result in sufficient fuel savings over five years to pay for itself), then it probably is worth doing. Students must learn about profits and losses, costs and benefits, and have a basic understanding of economics if they are to make sensible decisions as adults.

Energy and Food

Food is the energy source for human beings. The energy stored in growing plants is converted by our bodies into heat to keep us warm and into the motion of our muscles. In our modern technological society, food production is also a big consumer of energy. This energy is used on the farm for fertilizers, irrigation, and farm machinery, in food processing plants for cleaning, cooking, and packaging, in transportation and sales, and in our homes for food preparation. Each calorie of food we eat requires five to ten calories of energy to bring it to our dinner tables. As the cost of energy increases, the cost of food will also increase. We must all realize that food and energy are intimately related.

Energy Conservation

Most adults living today grew up in an era of cheap and readily available energy resources. We have begun to realize that our fossil fuel reserves are finite and that as these resources are used up, the cost of energy will increase. It is imperative that children in our schools and all of us realize the value of energy conservation. In order to conserve this precious resource we must understand how energy can be used most efficiently and what are effective means of energy conservation. Through careful planning and consistent application of conservation principles, we can stretch our reserves of non-renewable energy resources while we learn how to develop renewable resources to replace them. The smooth transition to a secure energy future may depend on our ability to conserve now.

HOW SHOULD WE PROVIDE ENERGY EDUCATION TO STUDENTS IN OUR ELEMENTARY SCHOOLS?

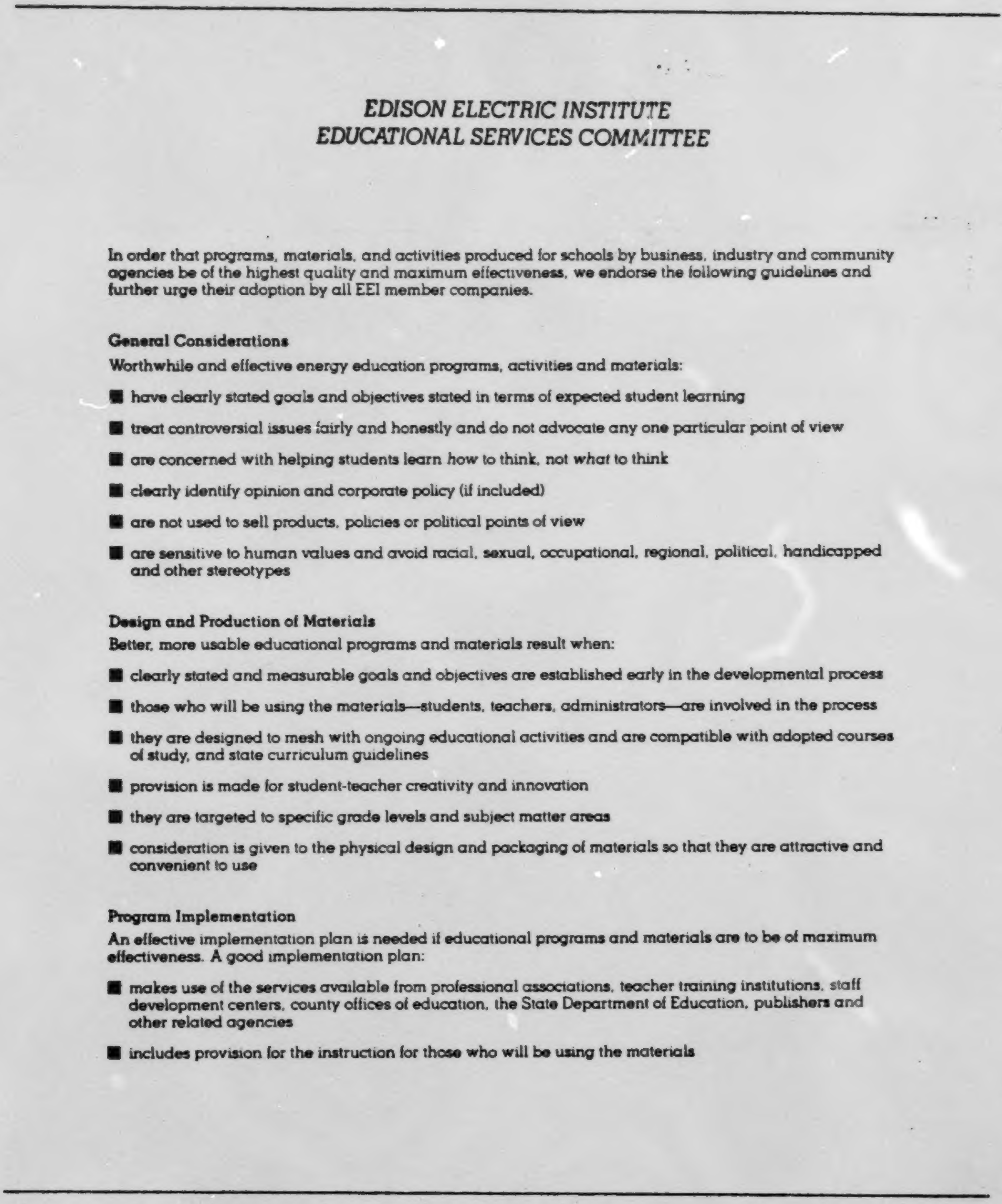
Most energy concepts appear to be abstract and can be difficult to visualize. Yet research on the intellectual development of children makes it clear that most elementary school age children are really able to think only in concrete terms. How are we to resolve this apparent dilemma of teaching abstract concepts to concrete thinkers?

The answer is to provide concrete experiences which children can use as the basis for future abstract thought. What is needed is a variety of "hands on" experiences with energy, to see it and feel it in action. Students must bring about energy conversions themselves and use real energy resources rather than reading or talking about them. They must be placed in positions where they have to make decisions, weigh risks and benefits, and discuss values. Of course teachers can develop their own energy-related activities and games. However, a large number of curriculum materials have already been cooperatively developed by teachers and other agencies. What follows is a description of these resources, some suggestions on how to evaluate and use them, and a listing of places where they may be obtained.

RESOURCES

A reference library of curriculum materials already exists for use in the elementary energy education program. Although science teachers are characterized by their ties to the textbook (90 percent of all science teachers use the textbook 90 percent of the time), there is a growing realization of the necessity for updated resources for classroom use (Yager, 1982). The impact of the information explosion in society today makes it imperative for teachers to utilize publications and data banks that supply current information. Fact sheets, brochures, pamphlets, and audio-visual presentations on vital energy topics provide a supplement to a dated science textbook. Joint efforts between elementary schools, utility companies, business and industry, and state departments of education are becoming commonplace. These cooperative ventures are not without their critics (Harty, 1978).

To ensure the use of quality materials, a number of associations have developed criteria for the production and evaluation of resources. The following guidelines (see Figure 2) are representative of those prepared by several organizations. In the development of these guidelines, the Educational Services Committee of the Edison Electric Institute incorporated a number of the recommendations formulated by the California Energy Education Forum. They are listed in the EEI 1982 Directory of Educational Services (Purdy, 1982, p. 1) as guides for those interested in the production, distribution, and use of school materials, programs, and activities for energy education (see figure 2).



EDISON ELECTRIC INSTITUTE EDUCATIONAL SERVICES COMMITTEE

In order that programs, materials, and activities produced for schools by business, industry and community agencies be of the highest quality and maximum effectiveness, we endorse the following guidelines and further urge their adoption by all EEI member companies.

General Considerations

Worthwhile and effective energy education programs, activities and materials:

- have clearly stated goals and objectives stated in terms of expected student learning
- treat controversial issues fairly and honestly and do not advocate any one particular point of view
- are concerned with helping students learn *how* to think, not *what* to think
- clearly identify opinion and corporate policy (if included)
- are not used to sell products, policies or political points of view
- are sensitive to human values and avoid racial, sexual, occupational, regional, political, handicapped and other stereotypes

Design and Production of Materials

Better, more usable educational programs and materials result when:

- clearly stated and measurable goals and objectives are established early in the developmental process
- those who will be using the materials—students, teachers, administrators—are involved in the process
- they are designed to mesh with ongoing educational activities and are compatible with adopted courses of study, and state curriculum guidelines
- provision is made for student-teacher creativity and innovation
- they are targeted to specific grade levels and subject matter areas
- consideration is given to the physical design and packaging of materials so that they are attractive and convenient to use

Program Implementation

An effective implementation plan is needed if educational programs and materials are to be of maximum effectiveness. A good implementation plan:

- makes use of the services available from professional associations, teacher training institutions, staff development centers, county offices of education, the State Department of Education, publishers and other related agencies
- includes provision for the instruction for those who will be using the materials

Figure 2. Guidelines for the Production, Distribution, and Use of School Materials, Programs, and Activities.

INFORMATION SOURCES FOR ENERGY EDUCATION

In the light of the information explosion in society today, it seems inappropriate to list publications and other resources that become outdated so quickly. The writers encourage teachers and curriculum planners to stay abreast of the current trends and new information presently being disseminated on energy education. Communication with professional/educational associations, business, industry, and state and national governmental offices will facilitate this process. For your convenience, the writers have listed a few sources of publications on energy education. Although the list is not comprehensive, it is an attempt to highlight representative groups that contribute to the success of energy education programs. Readers are encouraged to expand the list to include other organizations to complete this reference. Inclusion in the list does not mean endorsement by the writers.

ENERGY EDUCATION

Bibliographies and Current Resource Lists

ERIC/SMEAC
1200 Chambers Road
Columbus, OH 43212

National Science Teachers Association
1742 Connecticut Avenue, NW
Washington, DC 20009

Sources of Curriculum Resources and Publications

American Gas Association
1515 Wilson Boulevard
Arlington, VA 22209

American Petroleum Institute
2101 L Street NW
Washington, DC 20037

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Washington, DC 20014

Edison Electric Institute
1111 Nineteenth Street
Washington, DC 20036

Energex Energy Education
P.O. Box 7000-136
Palos Verdes, CA 90274

Energy and Man's Environment
4980 West Amelia Earhart Drive
Salt Lake City, UT 84116

Innovative Communications, Inc.
2923 North Main Street
Walnut Creek, CA 94596

Iowa Energy Policy Council
215 E. 7th Street
Des Moines, IA 50319

Joint Council on Economic Education
1212 Avenue of the Americas
New York, NY 10036

National Council of the Social Studies
3615 Wisconsin Avenue, NW
Washington, DC 20016

National Science Teachers Association (NSTA)
Project for An Energy-Enriched Curriculum
1742 Connecticut Avenue, NW
Washington, DC 20009

National Wildlife Federation
1412 Sixteenth Street
Washington, DC 20036

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509

New York State Energy Office
Agency Bldg. 2
Empire State Plaza
Albany, NY 12223

Philadelphia Electric Company
the Pennsylvania Energy Education (Advisory Council)
2301 Market Street
Philadelphia, PA 19101

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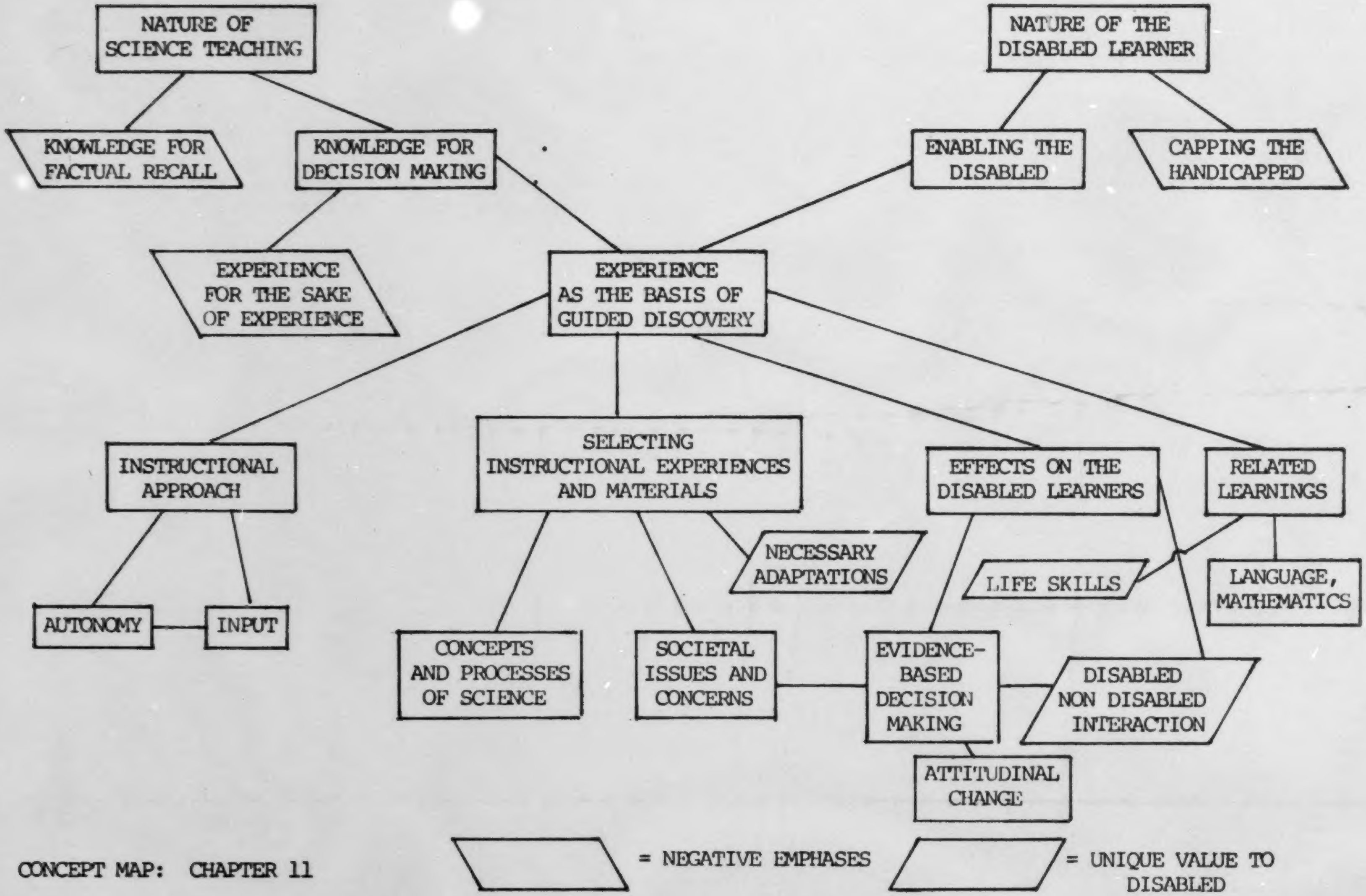
NATURE OF SCIENCE TEACHING
NATURE OF THE DISABLED LEARNER
KNOWLEDGE FOR FACTUAL RECALL
KNOWLEDGE FOR DECISION MAKING
ENABLING THE DISABLED
CAPPING THE HANDICAPPED
EXPERIENCE FOR THE SAKE OF EXPERIENCE
EXPERIENCE AS THE BASIS OF GUIDED DISCOVERY
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= NEGATIVE EMPHASES
= UNIQUE VALUE TO DISABLED

CONCEPT MAP: CHAPTER 11

CHAPTER 11

SCIENCE TEACHING AND SPECIAL EDUCATION CONCERNS

HERBERT D. THIER

INTRODUCTION

Historically, disabled individuals have received little science education in their school careers. This is clearly evidenced by the small number of disabled individuals currently pursuing careers in science, technology, or related areas (AAAS, 1980). Reasons ranging from "they need to concentrate on fundamentals and don't have time for science" to "they can't use the equipment, read the thermometer, get to the work bench, or will hurt themselves" have been used implicitly or explicitly to explain the lack of science education in the school careers of disabled individuals.

Federal, state, and local regulations and policies requiring equal educational opportunity for the disabled (PL 94-142 and others) have brought about many changes including mainstreaming (the placing of disabled students in regular schools and classrooms) and many disabled individuals now have the same opportunity to study science as the nondisabled individual. Unfortunately for all, and especially in the case of the young learner, this still frequently means little or no real science education in the elementary or early secondary school (Stake and Easley, 1978; Harms and Yager, 1981).

National concern over the lack of science for all learners is being expressed by groups as prestigious as the National Academy of Sciences (National Academy 1982) and the President's Commission on Educational Excellence (1982).

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These concerns apply to all citizens, whether disabled or not. Early science experiences are valuable and important in the development of all learners, but they are absolutely essential if disabled individuals are to achieve their academic and social potential. The purpose of this chapter is to describe and explain the unique and essential role early and continued science experiences can play in enabling disabled individuals to develop their potentials to the fullest.

To accomplish the purpose of this chapter it is necessary to first look briefly at the nature of science teaching and at the nature of disabled individuals. Then it will be shown how science experiences can be used to accomplish a wide variety of specific objectives while enriching and enlarging upon the educational and life experiences of disabled individuals.

NATURE OF SCIENCE TEACHING

Education is the learning of facts and how to use them as part of decision making about problems and issues of concern and importance to individuals and the society in which they live. If all that education does is provide facts, the result is human encyclopedias. On the other hand, if education tried to teach decision making without a factual reference frame, chaos would soon set in.

Speaking recently at a conference on the American high school, Gus Tyler described education succinctly as a combination of rote and reason (Tyler, 1982). Rather than waste time arguing whether rote or reason is more important, our responsibility as educators is to find ways to effectively and efficiently blend rote and reason to bring about quality education for all. Learning to read, write, and compute requires considerable rote learning, especially in the elementary and early secondary school. Each of these subjects provides many opportunities for strengthening the reasoning side of education but usually the only reasoning is related to how effectively one has mastered the rote side of education. For example, if one does not know the times tables, word problems involving multiplication are very difficult, time consuming, and virtually impossible to handle.

Science, with its emphasis on evidence and use of mathematics and natural language, can provide unique opportunities for all students to use and develop their reasoning abilities. Whether or not this takes place is determined by the kind of science taught. Biology at any level, for example, can be another foreign language concentrating on the learning of new words to name and describe organisms and processes. It can also be an introduction to the wonders of life and all of the opportunities for analysis, synthesis, and greater understanding which become available with its study. Facts are needed but the quality of the science program is determined by the context in which the facts are learned. The learner can be considered to be an empty vessel to be filled with certain facts each class period or week and then evaluated by how many facts the vessel is able to accurately pour out of its spout. This type of science program is focusing only on rote and is a poor excuse for science teaching. On the other hand, if each science class is another disconnected "gee whiz!!" "magic-like" experience provided at the end of the day "because the students are too tired to learn anyway," then at best you have experience for the sake of experience. That also does not come close to the possible educational potential of the science program.

Quality science teaching at any level is "experience based." The evidence collected by the learner is combined with the factual and procedural input provided by the teacher and other sources in order to evolve in the learner the knowledge, confidence, and interest necessary for effective decision making. Therefore, the competent science teacher blends direct and indirect experience with the necessary factual and procedural input in order to accomplish what we will refer to as Experience as the Basis for Guided Learning. Such an approach to science teaching includes the "rote" but certainly emphasizes the "reasoning" aspect of education. Especially for the disabled learner, science provides many opportunities for necessary related learning experiences in fields such as mathematics, language, and everyday application skills.

NATURE OF THE DISABLED LEARNER

The term handicapped traditionally was often used to categorize individuals in order to describe what they could not do and how we, the nonhandicapped, had to take care of them. The very term handicapped comes from the old English and evolved to describe the begger "cap in hand" asking for alms. Too often our approach in education has been similar. We tested the so-called "handicapped" individuals, determined what they could not do, and then described an educational program for them that emphasized care and dependence. Done many times for what were thought to be the best of reasons, such approaches were and are unfair both to the individual and society. Individuals are discouraged from accomplishing their potential for independence. This commits society to implied acceptance of a life-long period of costly care for and dependency by the individual. Essentially such programs "cap the handicapped" by determining early what they cannot do and then adjusting both their educational programs and their aspirations to these limitations. We have had extensive experience working with seriously disabled youth ranging from the congenitally blind to the severely cerebral palsied (no verbal speech). Our experience indicates that for all disabled youth there is significant potential and capability for learning.

Needed is an instructional system designed to maximize their capabilities and minimize their disabilities.

Disabled individuals tend to lack some of the experiences of their nondisabled peers. They tend to be highly motivated to learn, especially when you are able to design an instructional experience so that they can really take part in it. Disabled individuals are strongly motivated to become independent and are willing to work long and hard to master a skill or procedure. They, like all other individuals, need many challenging and interesting learning experiences. Disabled individuals then explore and extend their own limits rather than having outsiders arbitrarily set limits for them based on what the outsider believes a person with that disability can do.

SCIENCE EXPERIENCES AND THE PHYSICALLY DISABLED INDIVIDUAL

The educational emphasis that is necessary for the disabled is one of "Enabling the Disabled Rather than Capping the Handicapped." Not necessary is carrying out research studies to determine what disabled individuals cannot do. We need to first identify the critical information, ideas, and issues necessary to understanding a topic. We can then work on developing and testing out an instructional system that enables disabled individuals to gain that understanding in a context that contributes to their self-confidence and self-image. School can only be an introduction to learning if we consider learning to be a life long endeavor. Therefore, for disabled individuals, just like their nondisabled peers, it is necessary to transmit and develop the information and understanding that is necessary for individuals to become independent, contributing members of society. In addition, and more important, it is necessary to help individuals, disabled or not, to learn how to learn. Then, whether it be in the world of work or as participating citizens in our democracy, individuals will be able to adapt to changes, process and analyze new information, and make intelligent decisions based on the evidence.

Our whole society is becoming more dependent on science and technology every day. We expect our citizenry to make a wide variety of science- and technology-based decisions in the world of work and in life generally. Therefore, science and related fields have become extremely important in the educational experience of all learners. For disabled learners, science instruction starting at an early age and continuing throughout their school career takes on added importance for the following reasons:

1. Science emphasizes hands-on experience and exploration of the environment, both physical and biological. It can help to fill some of the

experiential gaps in the background of many physically disabled individuals. Whether these gaps have evolved because of extensive hospital stays, overprotectiveness of schools or parents, or a variety of other reasons, these hands-on experiences are essential in developing knowledge and understanding of one's environment and one's personal relationship to it. Such understanding is extremely important in helping to develop the individual's independence and overall positive self image.

2. Recent scientific and technological advances have provided the tools (computers, talking calculators, control systems, versabraille hook-ups to computers, TTY telephone systems, etc.) which can help to mitigate the limitations imposed by the disability. This can help enable disabled individuals to be independent, contributing members of society. In order to effectively use these technological devices, disabled individuals need first to know about them. Also helpful is a variety of experiences exploring variables, using equipment and materials, and generally getting over fear and apprehension regarding machines and related devices. Many of these technological devices involve organizing and inputting information. Science instruction with its emphasis on making observations, collecting and organizing evidence, and coming to conclusions, can be significantly helpful in developing the individual's psychological and manipulative readiness for using technological devices.

3. Job opportunities in the future for all individuals will require greater knowledge and understanding of technological devices and how they work. The computer will become an important part of many jobs in the future. Because of technological advances in alternate ways for individuals to use computers, many of these jobs are available even to the seriously disabled if they have the necessary background and training, and perhaps more importantly, self-confidence to seek the position. As described above, early experience-based science education can help disabled individuals to develop the skills and attitudes necessary to effectively take their place in the world of work as independent contributing members of society.

Designing and putting into action a science program for any group of learners is a complex and demanding task. Instructional experiences and materials need to be selected, the approach to instruction needs to be decided, and the involvement of the learners in their own learning needs to be planned effectively. This is true whether or not the group of learners includes physically and/or learning disabled individuals. Since mainstreaming is to a great extent the philosophy of the land, any science program, especially at the elementary and early secondary level, can expect to have one or more learning and/or physically disabled individuals in any class.

It is important to note that in all of our work over the past 13 years designing materials and instructional approaches for physically and learning disabled individuals of all ages, two consistent outcomes have emerged. First, irrespective of how disabled the individual or group may be, there is a way to help them have interesting and effective science experiences that lead to understanding. Second, any time we have come up with a modification that has enabled disabled learners to experience and understand some aspect of science more effectively, that adaptation has proved to be an outstanding science experience for all learners, especially the nondisabled. Therefore, the principles and approaches described below to help meet the specific and unique needs of disabled learners are really principles and approaches for effective science teaching for all learners.

In summary, physically disabled individuals have deficiencies and cannot perform certain functions in the same way as the nondisabled or, in some cases, cannot perform them at all. A great deal of educational planning and programming for the disabled has focused on these deficiencies and what individuals could not do rather than on adaptive approaches to meet the individual's needs. Significant legal and policy changes at all levels have set the stage for a more enlightened view of the physically disabled and their educational needs. Technological and scientific advances, especially in alternate modes of exploring and expressing ideas brought about by advances in computers and related fields, have gone a long way toward minimizing the individual's disability and maximizing capabilities. Science education, which has its emphasis on Experience as the Basis for Guided Learning, can play a unique role in providing young physically disabled individuals with information, understanding, and experience. This can help them develop competency and the self-confidence needed to benefit from the opportunities available to them through technology.

SELECTING INSTRUCTIONAL EXPERIENCES AND MATERIALS FOR DISABLED LEARNERS AND THEIR NONDISABLED PEERS

The nature and complexity of science is such that no course or even total school program in science can hope to cover all aspects of science. Choices need to be made, and it is these choices which determine the nature and impact of the learner's experiences. Many elementary and junior high school textbook series choose to survey as many aspects of science as possible and so provide interesting facts and information about a great many topics. They even highlight the variety of topics covered in scope and sequence charts used to promote the materials. Often such a choice leads to a "reading about science" program, with the textbook becoming the core of the program and actual science experiences supplementary or optional. Contrast this with a program like the Science Curriculum Improvement Study (SCIS) (Thier et al. 1978) at the elementary level or the Introductory Physical Science program (IPS, 1967) at the early secondary level. Here a modern view of the nature and structure of science is used as a basis for the selection of experiences and activities to get across a selected set of content and process objectives. The intent is to develop an understanding of the nature of science, or parts of it, as a field of inquiry. The emphasis is on the learner actively participating in the learning experience, collecting evidence, using the evidence to make decisions, and then using those decisions to organize ways to collect new evidence. Far fewer topics can be introduced and fewer facts are learned. The emphasis instead is on scientific thinking rather than just learning the facts of science. This kind of science highlights the "reason" rather than the "rote" side of education and promotes the atmosphere of Experience as the Basis for Guided Learning which we have found to be so beneficial for disabled learners and their nondisabled peers.

In spite of advances over the past decade, the quantity and quality of science instruction available to all children at the elementary and early secondary level is still woefully low. Contrary to the continued success of some programs, "hands-on" science generally is not capturing an increasingly larger percentage of the market place. In some areas a return to textbook teaching about science or no science teaching seems to be increasing for economic and "less work for the teacher" kinds of reasons.

All of the evidence seems to indicate that in many classrooms for the present time and into the foreseeable future, an emphasis on enrichment of the science textbook program is needed. Providing meaningful, easy to use, hands-on instructional experiences for learners is a viable and effective way to improve the science education experiences for all learners, especially the physically and learning disabled. This is the approach taken by the SAVI/SELPH program (SAVI/SELPH, 1981), a set of materials first developed and field tested with blind and visually impaired youngsters and later improved upon and extended to learners with other physical disabilities, the learning disabled, and their nondisabled peers.

THE SAVI/SELPH PROGRAM AS AN EXAMPLE OF THE APPROACH TO SELECTING INSTRUCTIONAL MATERIALS

The procedures and approaches utilized to select instructional experiences and materials for the SAVI/SELPH program will be used as a real world example of an approach to carrying out the task of designing science experiences and materials for young disabled learners and their nondisabled peers. First and foremost, for the reasons described earlier in this chapter, the decision was made to emphasize actual hands-on experiences with the materials and processes of science. Furthermore, considering the sensory and experiential deficits of many disabled learners, the decision was made to use a multisensory approach to all activities, thereby providing input through as many senses as possible. In this way, sensorially deficient learners (e.g., blind or limited sight) would have other opportunities to experience the activity (touch, hearing, etc.) while other disabled youngsters who have been deprived of experiences would have opportunities to use and develop all of their available sensory inputs.

The purpose of the program is to teach science to the disabled. The modules and activities included were selected on the basis of a number of criteria. Each of the criteria is described below with an example of an activity or module from the program that was included to help meet that criterion. Following the criteria in Table I, an overview of all the SAVI/SELPH Module descriptions and activity titles is given so that the reader can get some appreciation of the outcome of this process of instructional experiences and materials selection.

1. Surveys of teachers of the disabled indicated these were topics in which their students showed interest and concern. Many teachers surveyed indicated a desire for life science activities. Especially mentioned were growing plants and experiences with animals. The Structures of Life, and Environments modules provide extensive multisensory experiences with plants and animals. For example, after considerable effort trying various organisms, the crayfish was found to be an interesting, hardy, easy to maintain animal. Its size, rate of movement, and response to stimuli made it possible to design an effective series of multisensory experiences for individuals with a wide variety of disabilities.

2. Modules and activities were chosen to represent the various major branches of life and physical sciences. They were also chosen to include topics of current societal and practical importance. A review of Figure 1 clearly indicates the variety of life and physical science experiences included in

SAVI/SELPH Module Descriptions and Activity Titles

Measurement module. This module contains four activities that introduce your youngsters to standard metric measurement. The students use a variety of specially developed tools that not only permit easy measurements, but help to stimulate the development of manipulative skills. (*The First Straw, Take Me to Your Liter, Weight Watching, The Third Degree*)

Structures of Life module. The primary goal in this module of seven activities is to provide experiences with both plants and animals and to help the students learn something about the organisms they explore. The two major concepts that students explore in this module are *growth* and *behavior*. (*Origin of Seeds, Seed Grams, The Sprouting Seed, Growing Further, Roots, Meet the Crayfish, Crayfish at Home*)

Scientific Reasoning module. The five activities in this module are designed to help students develop skill in making observations and processing the information they obtain from those observations. These activities are concerned with the concepts of *variable* and *controlled experimentation*. (*Jump It, Howdy Heart, Swingers, Plane Sense, Rafts*)

Communication module. This module contains four activities dealing with the physics of sound. The specific goals include: sharpening the students' sound discrimination skills; helping the youngsters become familiar with sound sources, sound receivers, and sound amplification; introducing the concept of *pitch*; and bringing the youngsters to an understanding of the relationship between vibration and sound. (*Dropping In, Small Sounds Big Ears, What's Your Pitch?, Vibration = Sound*)

Magnetism and Electricity module. The four activities in this module provide your students with the basic concepts of *magnetic attraction* and *repulsion, circuit, insulator, conductor,* and *electromagnetism*. These concepts are integrated as the students build a telegraph and send coded messages. (*The Force, Making Connections, Current Attractions, Click It*)

Mixtures and Solutions module. This module contains four activities that are designed to introduce your students to the concepts of *mixture, solution, concentration, saturation,* and *evaporation*. These activities also foster growth in manipulative skills (e.g. measuring, transferring, and filtering), organizational ability, and observational skills. (*Separating Mixtures, Concentration, Reaching Saturation, The Fizz Quiz*)

Environments module. The four activities in this module introduce your youngsters to the concept of *environment* and provide them with a means of discovering which factors make an environment a suitable place for an organism to live. During the course of their investigations, the students find that different organisms require different types of environments, and that a suitable environment fosters growth and survival. (*Environmental Plantings, Sea What Grows, Isopods, The Wanted Weed*)

Kitchen Interactions module. The four activities in this module provide experiences with common household substances: baking soda, yeast, lemons, salt, and cookies. These somewhat higher-level activities call upon several techniques and tools introduced in other SAVI modules, e.g. controlled experimentation and metric measurement. (*The Acid Test, How Dense?, The Cookie Monster, The Sugar Test*)

Environmental Energy module. In this module of four activities, the youngsters construct solar water heaters and pinwheels to collect environmental energy from the sun and wind. (*Solar Water Heater, Sun Power, Blowin' in the Wind, Wind Power*)

Figure 1. SAVI/SELPH Module Descriptions and Activity Titles

the program. Activities of growing salt-tolerant plants and others of collecting and measuring solar and wind energy provide the desired experiences related to societal concerns. In the Measurement Module, students apply knowledge of the metric system and how to measure in some very practical situations. The participants learn adaptive techniques they can use when making measurements.

3. Activities were chosen that included opportunities for providing instruction and experience in using the major processes of science as an integral part of the learner's activities. Concepts such as variable and controlled experimentation are introduced in the SAVI/SELPH Scientific Reasoning Module as students measure their own heartbeat rates before and after exercise. In another activity they explore variables and controlled experimentation in a different context as they explore the effect of thickness on how many washers a raft can hold. Modifications were made, such as a plastic fence to make it easier to get the washers to stay on the raft and a magnet attached to a stick to help get them out of the water after the raft sinks. This makes it possible for seriously physically disabled individuals to experience this activity.

4. Activities and experiences were chosen that had significant relevance to the everyday lives of the participating learners. As can be seen from the brief descriptions in Table 1, students have opportunities to learn how to make measurements for themselves in spite of their disabilities. They also learn in Magnetism and Electricity how to use switches and simple tools such as screwdrivers. In the Kitchen Interactions Module students apply what they learned in the Measurement Module about the metric system to a variety of situations using materials common to everyday experiences. For example, in the acid test baking soda is used to test for the presence of acid in a variety of common foods. The adapted devices introduced to help in making the measurements have practical uses in the everyday lives of the students.

5. Activities and experiences were chosen that provided extensive opportunities for related learnings in fields such as mathematics, language, and social science. For example, regarding mathematics, the "See Grams" activity in the Structures of Life Module introduces the students to histograms, while "The Force" activity in the Magnetism and Electricity Module introduces

graphing of data and using the graph to make predictions. A quantitative approach is taken in many activities. "Dropping In" in the Communication Module and "Click It" in the Magnetism and Electricity Module both provide students with opportunities to use and extend their language abilities as they make up codes and send words to each other. The work on solar and wind energy in the Environmental Energy Module can be used as the introduction to a social studies unit on energy.

DETERMINING THE APPROACH TO INSTRUCTION FOR PHYSICALLY DISABLED LEARNERS AND THEIR PEERS

Once the commitment to use experience-based multisensory science materials has been made, some of the approaches to instruction are already determined. For example, we can expect that learners will be spending much of their time exploring materials and gathering evidence rather than reading in a science textbook. Experience for the sake of experience with no other input is, however, a very inefficient way to foster real learning. What is needed are effective challenging materials for individuals to explore, combined with carefully planned interventions by the teacher or other instructional leader. Instructions, diagrams, and work or record sheets can serve some of this purpose of organizing and directing instructional experiences. None of these approaches currently can provide the reflective interaction and personal understanding provided by the knowledgeable, interested instructional leader. Continuing advances in computer assisted and other automated approaches to instruction can provide some of this guidance and direction for hands-on experiences without the use of the human instructor.

The value of human interaction with a knowledgeable leader is essential for all learners and especially the disabled. Disabled or any other learners may have problems working with any automated system of instruction and need help. More importantly, especially for the disabled, is the fact that no machine can judge the temperament, emotions, or unspoken desires of the learner. The teacher, based on continuing interaction with the individuals, can know when to probe further, when to accept an answer even if it is not perfect, and, even more important, when to provide learners with additional time to explore further on their own or to just "mess around with materials" (Hawkins 1965) before introducing a new concept or asking for the kind of thinking that brings about conclusions and decision making. Especially for physically disabled learners, who may be sensorially and/or experientially deprived, this kind of time for self-directed or autonomous learning is very important.

Karplus (1981) has contrasted these two aspects of the instructional approach by referring to them as "autonomy" and "input." Effective instruction includes carefully planned opportunities for both autonomy and input on the part of the learner. However, autonomy does not mean total freedom any more than input refers to rigidity. Critical to quality instruction is the differing roles played by the teacher during periods of autonomy and input for the learner. For example, the kind, and quantity of instructional materials selected, the printed or other instructions provided, and the overall learning and emotional environment maintained all contribute directly to the value and effectiveness of autonomous activity by the learner.

The teacher's role is very important in selecting and sequencing the opportunities for learning in relation to the overall objectives for the program and the prior experience and demonstrated capabilities of the individual learner.

Learners are primarily involved in independent activity, working on their own and/or in collaboration with peers. The teacher should be available as an intelligent observer ready to step in and help individuals or groups over hurdles that are totally confusing them or leading them in unproductive directions. The teacher should not be breaking in so often that the learner's train of thought is interrupted and opportunities to benefit from the successes and failures of his or her own decisions are taken away. No one can write in a teacher's guide precisely when teachers should or should not become involved since it is a matter of judgment related to the materials being explored and the learners doing the exploring. Instructors who are constantly breaking in to be helpful need to reassess their role. Especially in working with seriously physically disabled learners, the situation becomes significantly more complex. Some physically disabled learners will need the help of an instructor, attendant, or peer very often during many learning experiences if the experiences are to be beneficial. Careful selection of activities and adaptation of materials and devices can help, but for some learners significant assistance will be required.

Even in these extreme cases significant real autonomy for the involved learners can be provided with careful planning. For example, a teacher was working with a severely cerebral palsied girl on a life science activity investigating variables in the growth of root vegetables. Students were instructed to plant one whole root vegetable in vermiculite, right side up, and then to plant other root vegetables or parts of root vegetables in various orientations (upside down, sideways, etc.) to see if they would grow and in what direction the roots and shoots would grow. With minimal instructions the activity provided great autonomy for the participants. The girl with cerebral palsy could plant no root vegetables since she had very limited controlled use of her hands. The teacher (a paraprofessional who knew her well) explained the possibilities and then let the student gesture and otherwise communicate to explain which vegetables she wanted to plant, whether she wanted to plant all or part of each, and in what orientation. The teacher then planted all of the vegetables for her and helped her arrange a watering schedule. The student did all the observing and drew her own conclusions. Vocal communication was difficult for this girl and she had little controlled use of her hands. An understanding teacher preserved her autonomy in the experience by simply carrying out according to her desires the parts of the activity she was physically unable to complete. The fact that the activity was carried out as part of an enrichment experience in a learning center (SAVI, 1981) with only three students made it much more feasible for the teacher to operate this way. The teacher's role when you are trying to encourage autonomy on the part of students is one of a pre-planner and designer of the instructional experience and a facilitator of the students' autonomy during the learning experience.

The teacher's role during "input" aspects of the instructional program is also one focused on facilitating learning. Carrying out the role, however, includes many activities more traditionally identified as "teaching". Input oriented sessions are effective for a variety of purposes, including introducing new ideas, suggesting a specific laboratory procedure and how to carry it out safely, and helping learners to pull together and analyze data and draw conclusions about the evidence they have been collecting. During input sessions a teacher might: (1) introduce new vocabulary, (2) demonstrate how to transfer data to a graph or chart to help highlight the trends in the data, or (3) introduce a new idea or understanding like system or energy so that students' explorations can be more effective. In all these situations significant and direct input by the teacher is necessary if instruction is to proceed effectively.

Careful planning and design of input oriented sessions is extremely important since teaching is not simply talking, especially if you are working with disabled youngsters and are committed to taking a multisensory approach in your instructional program. Carefully designed charts and illustrations can help many youngsters understand a point that would totally confuse them if the only input was aural. For those who can see, a well chosen picture can still be worth a thousand words. Giving some youngsters an outline or summary in print, or even braille, of what you are going to introduce can help them to better understand the ideas. Using examples from the students' recent experiences as the basis for the introduction of the new idea can be extremely helpful. Learning can be considered to take place in cycles and well designed learning cycles usually allow for a period of "exploration" or familiarity with the general idea or subject before the teacher "invents" or "introduces" the new idea during an input session. In the SCIS (Thier, et al., 1978) program can be found a further discussion of the learning cycle and especially its use in elementary school science. It is during input sessions that the art and showmanship aspects of teaching can come in effectively as long as the emphasis is always on evolving a climate for understanding on the part of the student.

For all students, but especially the disabled, just introducing a new idea cannot be considered adequate if real understanding is desired. Divergent questions (Thier, 1970) that encourage multiple responses can be asked to encourage youngsters to express their own understanding or lack of it about the new idea. Such questions are successful when they lead to an exchange of ideas and information between youngsters and the teacher or especially between youngsters themselves. Discussions can help individuals to try out and explore their ideas with their peers and here especially the teacher's role is one of a facilitator of the discussion rather than immediate provider of right answers. When the input session is designed to pull together and come to some conclusions about data previously collected by the students, the role of the teacher is also very important. The role here is to provide information and this should be done as effectively as possible, while keeping in mind that teaching can be listening (especially to learners) and learning can be talking, especially as individuals share, reflect on, and revise their ideas in discussions with peers. The learning center approach to instruction with its emphasis on small groups can contribute significantly to this kind of teaching.

Opportunities for autonomy and input in the experience of learners should be a continuing process. The learner's own (but usually guided) discoveries during autonomous periods lead to and form the basis for new ideas and generalizations emphasized during input periods. New ideas and generalizations now become the organizers for further discovery on the part of the learners in sessions that are more autonomous. Having suggested an approach to be used in selecting instructional materials and experiences, and having suggested the instructional approach necessary to carry out such a science program, the next section will focus on the possible outcomes for the learners as a result of their involvement in such a program.

OUTCOMES FOR DISABLED LEARNERS

Work with the SAVI/SELPH program has shown that experience-based science can contribute to accomplishing significant positive outcomes for disabled learners. Filling in of experiential gaps, an introduction to scientific and technological devices that can help the individual be more independent, and exposure to career awareness and career opportunities can all evolve from the disabled learner's study of science. Learning science with its emphasis on evidence-based decision making can have an impact on disabled individuals and their attitude toward themselves and especially their capabilities.

In science, you identify a problem or situation, make observations, and collect evidence regarding it. You then use that evidence as the basis for decision making regarding how to try to solve the problem or change the situation. You then carefully try out your decision and evaluate its effect. Each problem "solved" or situation "handled" leads to new understanding and the identification of new problems and situations. This is the nature of science, a continuous exploration of reality using current knowledge and understanding as the basis for the framing of questions and investigations leading to increased knowledge and understanding.

It is this inquisitive, exploratory, evidence-based attitude that we want to develop in the physically disabled individuals in regard to themselves. Individuals may have the same disability but the effects of that disability on each individual and the individual's best way of coping with the disability is a very personal matter. The more the individual can explore and communicate his or her strengths and weaknesses, the more effectively professionals can help the individual cope with the disability. For example, science and technology make it possible for seriously disabled individuals to control a motorized wheel chair using almost any part of their body. Head, foot, hand switches, toggles, pointers, and combinations are in widespread use and provide a degree of independence never thought possible for many individuals. Specific approaches to maximize the individual's capabilities are usually possible if one knows what the individual's capabilities are. If the individual is able to take an evidence-based investigative approach to determining his or her own capabilities, this can be of enormous help to the professionals working with that person. Note that the emphasis is on a solution, therefore one collects evidence regarding capabilities rather than disabilities. This is the attitude of science; scientists collect the evidence that is available, use it as effectively as possible to partially or completely solve the problem or answer the question, and then use the solution, even a partial one, as a stepping stone to greater accomplishment. Science can instill in the disabled individual this attitude of focusing on what one can do and how that can be applied. This helps the individual cope with the disability. Not all problems or situations are as obvious or usually as amenable to solution as the question of controlling a wheelchair. The more we can instill in disabled individuals this inquisitive, investigative experience and evidence-based attitude that is science, the more they can participate in and contribute to ways of helping themselves cope with their disabilities. This will help them find ways to emphasize their capabilities.

In addition to the positive impact taking a scientific approach can have on individuals and their handling of their own disabilities, science experiences can have a significant impact on the interaction of young disabled individuals with their nondisabled peers (MacDougall, et al., 1980). The hands-on science activity, with its emphasis on unique materials or ordinary materials used in a different way, provides a new experience that the disabled and nondisabled learner can share together. Adaptations need to be made so that disabled learners can participate right along with their nondisabled peers. Our research in the classroom (Chiba and Thier, 1982) shows that such experiences increase the positive interactions between disabled and nondisabled learners and builds a cooperative atmosphere in the mainstreamed classroom. Available are extensive teacher reports and other anecdotal evidence of this positive interaction extending beyond the science classroom and into the disabled learners' general interactions with their nondisabled peers.

Science experiences can have positive effects on the attitudes of disabled individuals in regard to themselves and their interaction with nondisabled peers. Science experiences can contribute significantly to related learning by disabled individuals. The emphasis on making observations and collecting evidence can easily lead to increased use of oral and written language as one describes one's observations and evidence to peers and others. When conclusions are drawn, the basis and justification for those conclusions needs to be communicated to others in oral or written form. This provides an opportunity for language development and enrichment. The fact that the focus is on what took place during the activity when the evidence was collected makes it easier for disabled individuals to participate in the discussion. The emphasis is not on some prior, or out-of-school activity they were unable to enjoy because of their disability, but rather is focused on the common shared experience. Since so much of science is based on the collection, comparison, and analysis of quantitative data, many opportunities for the use of mathematics become available and any of these situations can be used as an opportunity for teaching skills not previously learned.

In a hands-on, experience-based science program opportunities abound for learning and reinforcing skills useful in everyday life, ranging from the use of a screwdriver to how to measure and pour liquids and powders. This can be done in the context of the experience and the emphasis can be on maximizing the individual's capabilities rather than on highlighting their disabilities. These and a wide variety of other possibilities for providing meaningful learning experiences in the broadest definition of the term "learning experiences" become possible when a hands-on, materials-centered science program is an integral part of the overall educational experience of disabled learners.

SUMMARY

Scientific literacy and the ability to collect, evaluate, and use evidence as the basis for one's decision making is a cultural imperative for any participating member of a free society in this day and age. Whether deciding which similar item is a better buy at the supermarket, interpreting advertising and its claim in regard to the effect on one's own health or well being, or making major decisions as a voter on environmental or other major issues, the individual needs the ability to collect and analyze the evidence in order to make a reasonable decision. This is the overall reason why an effective science program which teaches these skills is a necessity in the experience of all learners, disabled or not. The science program, in addition, can have a significant effect on helping disabled individuals maximize their capabilities while minimizing the effects of their disabilities. This leads to greater independence and self-reliance on the part of disabled individuals. As educators, our responsibility toward and concern for each student, disabled or not, should be reason enough for providing the very best possible science program for all individuals.

If this sounds too altruistic to some in times when "hard economic decisions" are necessary, it is important to note that an independent, self-reliant disabled individual can be a fully contributing member of society. The alternative is the totally dependent individual who has to be cared for indefinitely at costs per year far in excess of the entire cost to provide an effective science program. Science education cannot solve all problems but it can make a significant contribution. From humane and economic points of view we can do no less than provide disabled individuals and their peers with the best possible science program. To do less is cheating disabled individuals and ourselves.

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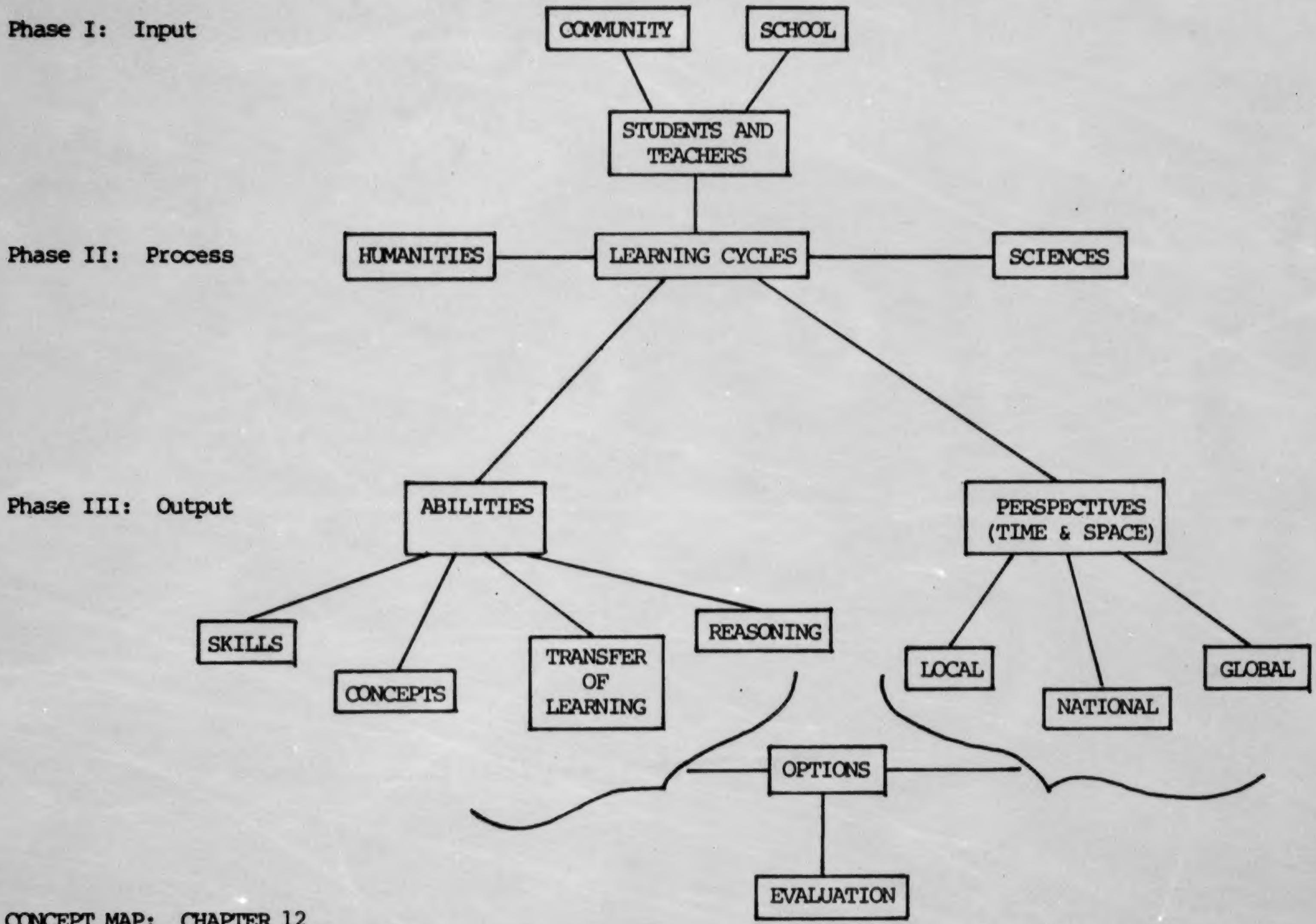
Phase I: Input
COMMUNITY
SCHOOL
STUDENTS AND TEACHERS
Phase II: Process
HUMANITIES
LEARNING CYCLES
SCIENCES
Phase III: Output
ABILITIES
PERSPECTIVES (TIME & SPACE)
SKILLS
CONCEPTS
TRANSFER OF LEARNING
REASONING
LOCAL
NATIONAL
GLOBAL
OPTIONS
EVALUATION

CONCEPT MAP: CHAPTER 12

CHAPTER 12

SCIENCE TEACHING AND CULTURAL CONCERNS

Richard C. Berne

and

Myra H. Jones

The current exponential increase in knowledge makes last year's "facts" as outmoded as the bustle. Our rapidly changing world demands that we as educators give our students more than a headful of unrelated facts. Students need the thinking skills to meet new and unguessed situations: the skills of *how* to think, *how* to solve problems. We must help students learn how to make connections among school subjects and between the school and real life. Therefore, we must shift our emphasis from "product" to "process," and we must integrate the two.

Many see elementary education as limited to emphasis on the basic skills--the three Rs. However, Hurd and Gallagher (1968) stated that a closer look at the knowledge explosion in science demands more emphasis on the intellectual processes of scientific thinking, in addition to a grounding in the basics.

AN APPROACH TO THE CHALLENGE OF THE KNOWLEDGE EXPLOSION: MOVING OUT OF THE CLASSROOM INTO THE COMMUNITY

One approach, which promotes exciting experiences for students and dramatic results for teachers, is to move out of the classroom into the community where real life situations become the text. The community becomes a laboratory in which abstract principles can be tested immediately against concrete reality. Such situations have built-in interest for the students.

A current cooperative venture between university and public schools illustrates how students and teachers are combining science study with cultural concerns, in the local settings, to promote critical thinking and problem solving skills.

In several elementary and middle-grade schools of the mountainous rural area of western North Carolina, students with interest in science and social studies formed an organization called S^3 ("S-Cubed" stands for "students, sciences, and society"). The students realized that local issues combine scientific and social concerns. The students, with their teachers, asked faculty from the nearby university to assist them in developing an interdisciplinary approach to the study of their in developing an interdisciplinary approach to the study of their local communities. One instructional focus centered around land, land use, and land use planning in their respective communities. Students looked at such questions as: What kind of construction is feasible for the land? How do different types of industry affect the soil quality? What kind of zoning do we have? What kind of long range planning is being done? What kind of sewage treatment? Water supply? What conflicts of interests arise between groups such as developers and conservationists, local people and part time residents, retired people and those in the work force? How are the conflicts resolved? What is the decision making process? Who participates in making the decisions? Who benefits?

Students did individual projects, and attended local public hearings and other meetings on topics such as potential mineral exploration of wilderness areas. They interviewed local leaders, sat on committees wrestling with land issues, did presentations for civic organizations, and otherwise became well-informed. They began to participate in the decision making process whenever possible.

The students were learning that important local issues are complex questions demanding both factual knowledge and rigorous methods of thinking that involve scientific, social, and political questions. Decision making is often a compromise among many points of view.

After studying their own community, some of the mountain students visited a school district on the Atlantic sea coast. For one week they stayed in the homes of students, visited in the local school, met and talked with community leaders, toured important local industrial and natural features, and observed the natural and man made environment of the area. Then, the coastal students visited the mountains for a comparable tour.

During the summer that followed, area teachers had the chance to take part in a similar experience through a summer institute on comparative ecology and culture. After an intensive look at the ecology and culture of the mountains, which included a visit to the nearby Foxfire Enterprises, the teachers visited a coastal biology research laboratory. There were several basic questions that both student and teacher groups were exploring: What is the relationship between the natural surroundings and the people who live there? What kinds of development are taking place? How does the natural environment influence or determine man's development? How are the ecological problems in different areas similar? Different? How do different communities approach their problems?

By examining their own surroundings in depth and then comparing their area to another, both teachers and students were learning to understand relationships, developing historical perspectives, and beginning to infer trends. They were learning to use their own communities as a microcosm of principles that remained valid on a global level.

Students and teachers agreed that this educational experience was the most exciting and memorable they had ever done. But why is community-centered, multidisciplinary learning so exciting? What is happening, and what are the benefits?

ASSESSING THE PROGRESS AND BENEFITS

Using the community as a classroom has many advantages--some more obvious than others--for the school and teachers, for the students, and for the community.

Meaningful Learning. When the students are studying real situations, in familiar surroundings, the teacher can capitalize on the interest that is already there.

Added resources. Using the talent and facilities available in the community, the school's resources can increase at very little cost, making possible much more variety in daily lessons.

Increased goodwill. When community people get involved as resource volunteers, they take a greater, and more friendly, interest in the schools.

Increased self-esteem of students and parents. Students and their parents feel good about themselves when they realize that familiar skills and knowledge are worthy of study.

More information available. The community itself benefits from the increased information gathered by the students. This information becomes part of the local historical or cultural lore or is added to the data base used by local decision makers.

There are more intangible benefits from the community-centered learning we are describing. Consider for a moment what subtle message is conveyed to the student when he gets deluged with the traditional textbook practice exercises and other such busywork, manufactured solely for classroom use. The implied message, which all too often comes through loud and clear (i.e., learning is artificial, confined to the school, and trivial). It has nothing to do with real life.

Community-centered learning conveys the opposite message; i.e., learning is a vital part of one's life to be carried on anywhere and everywhere and that which one learns (and what one does about what one learns) really does matter.

One hallmark of this type of learning is that it leads to excitement and involvement. While the students learn basic skills, they are learning how to use these skills to become effective citizens as adults--how to operate in the community's network of interconnected facilities and services.

Thus, while the community gains immediate benefit from the information gathered by student research, it stands to gain much more in the long run by having informed, involved citizens who are capable, wise decision makers.

COMMUNITY-CENTERED LEARNING: FACTIONS FROM TEACHERS

In the comparative environmental program described above, teachers stressed over and over that they anticipated several outcomes from a community-centered ecology study:

1. Students would begin to understand relationships and to make connections--that the principles operating in the familiar surroundings are the same principles in the nation and in the world.
2. They would become aware of the moral and ethical values implicit in scientific questions.
3. They would be involved in some way in action to help solve problems.

One teacher saw, and wanted her students to see, that man had lost touch with his environment: "Perhaps the most tragic aspect of technological development is that it has placed humans so out of touch with their resources." Her primary objective, she felt, was to "make students aware of ecological problems in their own community and how they contribute to the problems.... and to encourage students to think about the present problems, possible future problems, and, most importantly, possible solutions."

Another teacher was struck by the interdependence of the mountain and coastal regions and that "there is much here for thought and for careful scientific investigation." He also felt that "it seems extremely important to encourage students to become involved in looking at and preserving their heritage. Assignments to interview senior members of the community, visit and photograph landmarks, look at land records, and other things of this nature could result in projects which could be compiled for others to appreciate."

The theme of interdependence, and the far reaching effects of one's actions, was, for one teacher, "a central theme to be taught to my students. . .altering their attitudes in treatment of chemical wastes and pollution. . . ."

A student exchange is a valuable learning tool, according to another teacher, because "it would give students a chance to see different lifestyles... and ecosystems" which would give students "insights into the problems we are facing in the world. Another essential benefit is that of developing young minds that will have an effect on the future and will know how to change or cope with the problems facing the world."

Through experience, the teachers came to see how science is bound up with cultural and ethical concerns, and they felt the importance of conveying this to their students, as well as to fellow teachers.

GETTING STARTED

Now that we have discussed the benefits--even the necessity--of a teaching approach that combines science and cultural studies while utilizing the local community: How do we get it started? How is such a study organized, and what are some activities that can be done? What specific contributions do "Science" and "Culture" make to this new amalgam?

A major contribution of the natural and social sciences to the new mixture is the application of investigative models including observing, classifying, collecting and analyzing data, testing hypotheses, and communicating. These scientific skills and processes can teach children how to approach a new problem while the cultural concerns of the humanities provide a basis for forming values to put the problems in perspective. Thus, the qualitative perspective of the humanist, in combination with the quantitative findings of the sciences, provide the basis for a unified understanding of people and the world.

The investigative models, skills, and processes listed above are incorporated in a mode of learning, called a "Learning Cycle," which is described by Karplus *et al*. (1977). Essentially, a learning cycle consists of three phases including "exploration," "concept introduction," and "concept application." In the first phase, "exploration," the students explore their surroundings, new materials, and ideas, with little specific direction on the part of the teacher. In this phase many suggestions are made and many questions are raised by the students. An example might be to give the students a ruler, piece of paper, and a compass. Then, the teacher would allow the students to explore, suggest, and question the possible uses of such items. The teacher lets students become interested and develop the desire to know more.

The second phase is termed "concept introduction." This phase builds on the students' interests, a concept, or skill such as one related to mapping. The teacher introduces the skill through the use of the ruler, piece of paper, and compass. During this phase the student should gain some functional understanding of the specific concept, skill, or attitude introduced by the teacher.

During the third stage, "concept application," the student applies the newly learned concept, skill, or attitude to new experiences of different tasks. Practice, reinforcement, and transfer of learning occur during this third phase.

This learning cycle places the student in the position of needing to know. He is asked to apply his new knowledge or skill. This provides a sense of accomplishment. The learning cycle approach provides a class situation which demands active participation by the student and eliminates the old passive "force feeding" educational model.

A good way to begin organizing a local studies unit is to make a list of local issues. One can then identify some of the important questions about each, keeping in mind the steps of the learning cycle.

In one school teachers selected "Resources" as a general heading under which to place local issues. Listed below are some of the questions that teachers in our area thought important to a study of resources. Every one of the issues below has a local, a national, and an international aspect. Your community might be concerned with other issues and topics, but the samples below serve to show the process. This list was developed in a rural system, but the concepts, processes, and activities could easily be used in an urban system with little or no modification. Urban schools, in fact, will probably have an easier time planning a community-centered course. At least these schools will not have to travel 75 miles to the nearest museum or television station!

RESOURCES: GENERAL QUESTIONS

What are resources? Can man-made things be resources? Can people be resources? What resources are important in our community? Which "one" do we have here? Which (resources) do we have to get from somewhere else? Who owns the resources? Who controls their use? Who makes the rules about resources? How are the rules made? Which resources are scarce? Which ones are plentiful? How does our need for resources and our use of them affect our daily lives? How do conflicts arise between our need to use resources and our need to conserve them? What will happen in the future?

The above questions can be asked about resources in general; and they can also be asked with reference to specific resources listed below.

Land

How was land formed? How has it changed? What is land worth? Who decides? How do people feel about property? How do other groups (Indians, for example) feel about property? How are land ownership and use related to our family and community customs, daily habits, way of life?

Water

Where do we get our water? How do we use it? How is it made safe to drink? What happens to the water in our community when it leaves here?

Air

What is air? Where does it come from? Where does it go? What affects the air we breathe?

Energy

What is energy? What are the sources of energy in our community? How many types of energy do you see/use? How does our use of energy create ties with other communities? What will be our future sources of energy? What can I do to help conserve energy?

People

Who lives in our neighborhood? (Identify their races, religions, ages, social classes, economic levels.) How do the different groups get along? How do they not get along? Why? How do individuals behave? How do groups behave? Do individuals and groups behave any differently? Why? How is the population in our community changing? (Who is moving in, and who is moving out? Why?) How do groups of people influence one another? As groups? As individuals? How are disagreements settled? What jobs do people in our community have? How are jobs changing?

Institutions

What is an institution? What kinds of institutions do we have in our community? Why do we need rules? What kind of rules? Who makes the rules? How, why, and when do we change the rules? How do private interests sometimes disagree with public interests? Who pays for our institutions? Who gets the benefit from them?

Culture/Culture Change

Is there any one main group of people in our community? What examples of groups could you find? What kinds of things make up groups of people? Do some people belong to more than one group? What is culture? How is it changing? Why? How do things stay the same? How do the values of one group conflict with those of another group? How do the arts show what people consider important? (For example, what are the differences in rock, country, folk, and classical music? Compare fairy tales with modern tales, etc.)

Growth and Development

Is the size of our community changing? How? How fast? Why? Are there any limits to the growth of our community? What are they? Do we have enough green areas? Do we have enough institutions? Do we need more shopping areas? Why? How is growth affecting other resources, such as water, air, and energy? What makes you proud of your community? What would you like to change? How would you help make these changes?

Transportation

What kinds of transportation do we use? Why are there different kinds? Which kinds are best for which use? Which kinds are wasteful? How could our transportation be improved?

As can be seen from the nature of some of the questions, cultural concerns play a large part in the investigations suggested under each topic. The teacher should use cultural questions reflecting moral and esthetic values to underline all the investigations; the focus should stress how values affect and are affected by our development and use of resources.

The teacher can also draw correspondences between local and larger aspects of the same thing; e.g., how land ownership in the child's community is similar to and different from land ownership, in say, a third-world country. Children could compare how different topography in different communities (countries) will dictate different land use policies and values associated with land use.

It is important for the teacher to keep stressing the connection between the student and the material so the student will feel a personal stake in the learning that is taking place. This might be done by using as a guide such questions as:

1. Where did we come from?
2. Where are we now?

3. How is our community connected with our state, the nation, and the rest of the world?
4. What do we want the future to be like?
5. How can we make a difference?
6. What would be the best action for our community to take?

In developing a coherent plan for learning, the teacher can go through some process similar to the above, identifying issues and questions that lend themselves to development. It is also important to decide ahead of time what concepts, skills, and attitudes are to be developed, and then to choose a thematic approach broad enough to include most students, each with his or her particular area of interest and level of competence. One advantage to this learning approach is that it can be flexible enough to allow for student differences. There is something for everyone here.

The combining of individual and group studies and class projects provides a more thorough, sophisticated view of people, places, and issues. Each student or small group of students becomes responsible for one aspect of a given topic, and students learn from and teach one another.

A MODEL UNIT: LAND--A PRIMARY RESOURCE

A group of teachers from our area representing grades 4-7, chose the issue "Land: A Primary Resource" as the theme around which to base their curriculum. They identified ideas they wanted to explore in science and cultural studies related to land use. Those ideas were:

Science	Cultural Studies
1. The formation of land masses and oceans.	1. Map construction skills.
2. The formation of geological features in a region.	2. Present land use affects tomorrow.
3. Rock cycle--soil formation and soil types.	3. Land use, communities, and people are changing.
4. Mineral resources and their geographical distributions.	4. People's ways of living are conditioned by land uses.

5. Impact of climate on soils and land surfaces.	5. Historical record is useful in interpretation and prediction.
6. Man's impact on the environment in relation to land masses.	6. There is a relationship between natural order and social order.
	7. The individual can assist in finding solutions to personal and community problems.

Below are some activities that proved to be successful with students, as they learned about land in their community. The activities can easily be adapted for either a rural or an urban setting. They should suggest other activities which would work with your students.

1. Making Observations: Land Use. Let students, on the way to school, notice their surroundings. Ask them to

   a) describe how the land is used--how many churches? businesses? stores? homes? public buildings? vacant lots?

   b) discuss various land uses--which land is used wisely, which land use causes concern and why, how would students improve how the land is used?

   c) construct a map of their neighborhood in class.

   d) take photos or draw pictures of various uses of land.

   e) contrast uses of land in urban and rural areas; contrast and compare how the land is used in their neighborhood (country) with how other people use land.

   f) produce a simulation game around how to develop a vacant lot. Let students choose different positions on land use and defend them with written statements, arguments, and appropriate visuals.

2. Photographs: Springboards for Discussion. Ask students to bring to school photographs of their community or family from an earlier time, or borrow such photographs from local libraries or government agencies. From a larger number of photographs, have the students select ten or twelve that they think might be the most thought-provoking.

   a) Have students, or teams of students, develop a list of topics for discussion. These might include attempts to interpret the photographs to compare circumstances of then to now, questioning the value of "old" ways compared to contemporary lifestyles.

b) Let the students suggest activities. These might include such things as taking a survey, graphing survey results, making models, taking a set of modern photographs of the same subject material, showing how things have changed.

c) Resource people could be invited to explain and interpret the photographs.

Such a series of photographs for class discussion, entitled "Cultural and Historical Perspectives in the Tennessee Valley," was developed as a cooperative effort of public school teachers and students, university faculty, and the Tennessee Valley Authority. (These materials may be obtained from the Environmental Energy/Education Program, TVA, Norris, Tennessee 37828.)

3. Exchange Programs: Comparative Studies. As we have shown above, both students and teachers can benefit from comparing their community with another at first hand, by actually visiting that community. Here teamwork between administrators and teachers is needed to work together to find another interested school. It might be another school in the same system, or it might be farther away. City schools could team up with rural schools; mountain schools with coastal ones. An exchange need not be prohibitively expensive. If overnight (or several nights) stays are contemplated, students can stay in homes of their counterparts.

a) First, the partner school should be chosen. If possible, the schools should be doing similar class activities.

b) Participating students should be matched up so they can write letters to one another in order to get acquainted and compare their class studies.

c) Teachers and students should study the similarities and differences in the two communities before the actual visit.

d) During the visit children should spend time in classes, meet informally with the host students, and compare differences and similarities between schools. Then they should try to visit community facilities (industries, public facilities, etc.) that are different from those in their own home towns.

Even a one-day exchange visit can be rewarding if the teacher is careful to make sure that the students are adequately prepared.

4. Publishing a Newsletter: Community Findings. Some of the main objectives of a student newsletter would be to provide incentives for students to write about their observations and understandings and to be able to express their attitudes on issues. They would also be able to develop responsibilities for the production of this publication. This activity would help them learn to work together cooperatively. All students, regardless of ability, participate. Some students could be department editors; other students could contribute in some way--by drawing pictures, writing captions for them, pasting up copy, collating, finding "filler," and so forth. This function also serves as a practical summary of what they learned from the unit.

5. Slide, Tape, and Other Productions: Gaining Technical Proficiency and Poise. One of the most successful small group projects is that of producing a 35mm slide-audio tape program on a particular point of interest. Taking the photographs, editing the collection of photographs down to 40 or fewer slides, writing and editing the script, and then programming the audio tape with the proper sequence of slides is a real developer of self-confidence and poise for the students.

   Some topics for slide-tape programs are: plants and trees of the region, animals of our region, local architecture, people of our community, or our community then and now. Students could also develop a dramatic presentation written, produced, and performed by the students.

   Some students can collect photographs from older citizens of the community. These photographs can be converted to slides to produce an historical perspective to the topic presented. Another skill which might be developed would be that of interviewing, if adult community members are used in the production.

   Community resources which might be tapped are the local public library, historical society, radio station (for technical assistance), museums, hobbyists, and so forth. If the equipment for a slide-tape presentation is not available, the students could put together other kinds of presentations, such as a scrapbook and posters.

6. Simulations and Role Playing: The Processes of Issues. Have students develop a simulation reflecting decision-making procedures as related to a particular real community issue or issues, such as the location of a proposed road or shopping mall. The various persons and groups involved are then identified and their respective roles described.

After persons, offices, and roles are identified and described, a simulated hearing can be held to evaluate information and make a decision. It is imperative that students realize that one's position on an issue should be based on the most valid, unbiased information possible. However, they should observe that many decisions are based on considerations other than the best choice in terms of quantitative facts.

The students should learn the processes of decision making in a democratic society and how such decisions are fundamental to our way of life. If possible, the students could visit an actual community government meeting, such as a school board or county commission meeting. They could also invite local officials to class to explain different sides of the issue.

7. Community Festival: Something for Everyone. A special day could be established when the school would be open for a joint school-community celebration of something central to both: perhaps a Heritage Day or an International Day. The event could include demonstrations and exhibitions of adult, as well as student, skills, arts, crafts, performances, science projects, and so forth. The event could include special recognition of people, events, and places in the community. The theme of the entire program of study could serve as the theme for a community festival and might be a creative and enjoyable way to wind up the program.

8. Polling: People's Opinions. This activity would be a good way to introduce students to numbers and graphing. Have students review and discuss several polls gained from newspapers, magazines, and television. Then, have them construct a questionnaire related to a local issue. Using the questionnaire, let them conduct a poll and tabulate the results. Elementary students can make qualitative evaluations of the questionnaire and the results. Also, they can discuss what a "good" and a "poor" question might be, and how to get a representative sample. The teacher can introduce them to the techniques of propaganda and how it is used.

9. Student Dramatic Products: Application of Learned Concepts. The writing, directing, and performing of short plays, radio shows, or television productions are excellent vehicles for students to work cooperatively on a project that demonstrates their grasp of what they have learned.

   Students could prepare a morning closed-circuit television program for all classes in the school to view in homeroom. The program could include news, weather, announcements, and special topic productions.

If television facilities are not available, the older students could prepare short programs and take them into various classes. They could also prepare pamphlets that could be used by younger students.

Perhaps students could work on some production in school and then visit a local, cooperating television or radio studio to get the program taped.

10. Field Trips: Special Places. Every teacher knows the value of a well-planned field trip. Field trips are excellent vehicles for introducing or summarizing major topics. In addition, they provide opportunities for students to take photographs, raise questions, collect facts, and make comparisons. A follow-up session is important to make the most of the field trip. Follow-up could include discussions; producing a photo album or other record of the trip, and doing additional research, writing, art contests, and so forth.

11. Computers: A 21st Century Survival Skill. Currently the computer, along with textbooks, reference materials, and the calculator, has become another instrument in the instructional program. In addition to record keeping, testing, and other similar administrative uses, the computer can be an effective instrument in the classroom; its uses ranging all the way from remediation for children with learning problems to programs for gifted and talented students.

The computer is particularly good at helping students learn logical thinking patterns, demonstrating the results of interacting variables, and helping students understand the motion of synergistic actions. Of course, computers would be utilized to store and process information gathered by the students.

Not every school or school system is fortunate enough to have computers yet, but because they will be so important in our future, it is very important that students at least be introduced to computers and their uses, perhaps through some class study combined with a field trip. Many of the above activities might be included during the school year--providing a balance between classroom and nonclassroom activities.

We emphasize that even though the community offers many resources, the teacher must coordinate the planning and use of resource personnel and community resources. Parents and supportive individuals from the community are often helpful in doing much of the actual work, but the teacher retains responsibility for what happens in the educational program. Thus the teacher must not forget his/her role of resource coordinator.

This is a different learning pattern from the traditional one where the teacher is the authority who imparts knowledge.

Instead, the teacher becomes one resource among many from whom the students can seek help and guidance. Together, the student-teacher team can explore and examine questions of interest and importance. This learning pattern can be more rewarding than the old one.

SOURCES OF ASSISTANCE

In North Carolina there is a Community Schools Program which can be of great help to the classroom teacher. Participating school systems are staffed by a Community Schools Coordinator whose job in part is to locate all types of community resources, including volunteers, and help teachers utilize them. Many other states have similar programs. If this arrangement is not possible, a volunteer coordinator could be appointed.

Another major source of assistance exists in post-secondary schools with teacher-training programs. A mutually beneficial relationship can be established between the elementary school and the post-secondary institution. This relationship can result in a range of services such as tutors for students with individual in-service needs, faculty consultants with specialized expertise, and programs conducted by college faculty.

Additional resources are to be found in governmental agencies which often have personnel responsible for areas in which your students may be studying. The agencies at the local, state, and federal level might provide resource persons, printed matter, audio-visual materials, or facilities for field trips. One should be sure to take advantage of regularly scheduled programs.

Private industry and business are often overlooked as a source of assistance to the schools, yet they have responsibilities and commitments to the community where they are located. Often, such businesses welcome the opportunity to be supportive. In North Carolina, there is a statewide volunteer program called Adopt-a-School, which encourages industry and other organizations to adopt schools. The business firms agree to provide certain selected services to their respective adopted schools on a regular basis. Other states may have similar programs.

Professional and civic organizations often have educational committees or projects as part of their service contribution to the community. They offer a wide range of talent in many fields, and they simply need to know your needs and interests.

Private citizens, especially retired persons, enjoy being included on a limited basis. If you give them an opportunity to lend a hand, you will be surprised to find the array of expertise waiting to be asked.

Our own school-community project has been built upon the foundation of a public schools-university collaborative effort. Once our general direction and goals were established, we began receiving assistance from the following groups:

1) Western Carolina University
2) The Tennessee Valley Authority
3) The National Park Service
4) The National Forest Service
5) The Soil Conservation Service
6) Nantahala Power & Light Co.
7) Civic clubs
8) Industry and private businesses
9) Private individuals

After our project was under way, we were fortunate in getting added assistance from the National Humanities Faculty that provides aid to a project team of teachers in the fields of science, English, and social studies. This aid helps us integrate science and cultural concerns. Their help has taken the form of funding visiting scholars to work with teachers and students, a summer institute, and other services. Our project has been greatly enriched by the NHF, but a similar effort in your school system does not have to depend upon such support.

EVALUATION

The very large degree of teacher interaction with individual students (as well as with small groups and with the class as a whole) provides a continuous base for observing and evaluating student progress in the development of skills, concepts, and attitudes. The teacher can judge the student's maturation in social skills, including poise, self-confidence, and self-motivation. The student is performing closer to the level of his/her ability because he/she is working in areas that have much personal meaning for him/her.

There is also good opportunity for peer evaluation in these activities, and students can and will learn how to give each other suggestions, especially if they are working on joint projects. Peer evaluation is a good tool for the development of critical thinking skills.

OUTCOMES

You will find that some or all of the following will happen:

To The Teacher

You will rethink what is taught and how you teach it.

You will learn more in your chosen subject area.

You will make increased and more effective use of community resources.

To The School

There will be interest and support from the community.

There will be better mutual understanding between school and community.

To The Students

They will increase their skills and understanding.

They will be more interested in school. They will become involved in community affairs.

They will have increased pride and self-esteem and a sense of accomplishment.

We do not guarantee that the learning approach we suggest will be easier for the classroom teacher. Anything new and different will require effort. What we do guarantee is that both students and teachers will find learning fresher and more exciting if the teacher can broaden the classroom to take in the community, if science and culture can be integrated into a meaningful whole, and if the students become active in the pursuit of their own investigations.

SUMMARY

Most authorities on elementary science education agree on the importance of increasing early science education and of changing its direction. The American Association for the Advancement of Science (1969), for example, has urged a "dramatic revolution" in elementary science, which includes increased emphasis on the inquiry method, conceptual-level learning, independent learning (which promotes student initiative), skills in the processes of science to promote intellectual growth, and valid presentation of science materials (i.e., the basics).

Carl Sagan has long been an advocate of the importance of scientific literacy for everyone, not just for scientists. Sagan (1980) stated that science "is inseparable from the rest of human endeavor. It cannot be discussed without making contact, sometimes glancing, sometimes head-on, with a number of social, political, religious, and philosophical issues" (p.xiv). In a separate text (Broca's Brain) Sagan (1979) asserted, "Civilizations can be characterized by how they approach the ultimate questions, how they nourish the mind as well as the body" (p. 46). Sagan added, "The idea of science as a method rather than a body of knowledge is not widely appreciated" (p. 96). Sagan said that the school's responsibility is clear:

> I am often amazed at how much more capability and enthusiasm for science there is among elementary school youngsters than among college students. Something happens in the school years to discourage their interest...we must understand and circumvent this dangerous discouragement. It is clear that Albert Einstein became a scientist in spite of, but because of, his schooling (Sagan, 1979, p. 46).

This is the elementary teacher's challenge--to nuture the excitement of learning possessed by students and to promote it, to be sure that they acquire the basic skills, processes, concepts, and attitudes essential to a productive life.

APPENDIX

ACTIVITIES FOR LOCAL STUDIES: TEACHER-GENERATED ACTIVITIES

1. Have students bring in any cleaning solutions they use at home. Discuss contents and effects on the environment.

2. Take a field trip to a nearby water treatment plant.

3. Determine the pH of a creek near an industrial plant before and after a rain.

4. Have students research the history of the immediate area, the industry, and its development, and the effects of industry on the population.

5. Keep a city directory and telephone book in the classroom as sources for city and county government agencies, water sources and treatment plants, major industries, and utility companies.

6. Have students interview older people, such as their own grandparents, to discover for themselves what has changed in the last 50 years or so.

7. Have students draw a time line of the development of their community, supplementing it with photographs of historical and geological landmarks.

8. Have students chart the amount, by weight, of aluminum, glass and paper products their households throw away each week and suggest methods of reuse or recycling.

9. Take a field trip to the power company to see how the electricity supplying their area is produced.

10. Simulate a situation involving government and industry officials vs. environmentalists in conflict over pollution from local industries.

11. Have students design experiments to test the effects of acid rain, erosion, and pollution in their own neighborhoods.

12. Use a world map and/or globe in class to give students a sense of special relationships between water and land masses, as well as man-made political boundaries.

13. Have students trace all the energy they use in a day to its original source.

14. Have students construct a slide show illustrating the stages of succession and representative plants and animals of each stage.

15. Have students contact a representative of a government agency, such as the Soil Conservation Service, to determine what the current practices for conservation are.

16. Use microcomputer simulation or population growth to illustrate exponential growth.

17. Have students test the water they drink in the school for quality in terms of chlorine content, mineral content, and traces of metals.

SOURCES OF INFORMATION

Soil Conservation Service

The Sierra Club

U. S. Department of Agriculture--Forest Service

Bureau of Land Management

Nearby Universities

Weather Bureau

Forest Experiment Station

Geological Survey

National Park Service

Fish and Wildlife Service

Local Water Authority

Regional Air Pollution Control Bureau

TEACHER-SUGGESTED ACTIVITIES

Concept

Life is diverse.

Applications

1. Display 25-30 organisms found in the global community.
    - (a) Discuss name.
    - (b) Discuss habitat.
    - (c) Discuss structures.
2. Ask students to take a picture of organisms around their home and bring them to class and compare.
3. Take students on a field trip and discuss types of organisms seen (if possible let students take pictures for slide presentation).
    - (a) Local biology center
    - (b) Nearby forest or park (c) In an urban setting
4. Let students use Safari Card Set as a lab activity to let students see and read about global types of organisms.
5. Ask speakers to come to class with diversity of life knowledge from various ecosystems.

Community Resource

1. Collect at least 10 of the 30 organisms from the local community. Collect another 20 from different ecosystems.
2. Contact county and state agencies in your region to get samples of living organisms or written materials or pictures.
3. Contact county and state agencies in regions of other ecosystems to get samples of living organisms or written materials or pictures.
4. Contact a forest ranger in this area and have him do a presentation for class.
5. Contact persons from other ecosystems who would have the knowledge to do a presentation for class.
6. Ask students to bring pictures or slides to class of organisms from other ecosystems they have visited.
7. Ask a local biologist to do a presentation or conduct a field trip.
8. Ask a university professor to speak to class and show a slide presentation on the diversity of life.

9. Plan an overnight trip.

(Patricia G. Slagle, Andrews High School, Andrews, NC)

RESOURCE UTILIZATION KIT

Macon County, North Carolina, has developed a kit for elementary gifted students. This kit contains cards and other learning aids for students to help them learn to use resources, especially nontraditional resources such as folk artists, in independent research. The federally funded project, called RAGE (Realistic Alternatives for Gifted Education), is an attempt to provide affordable enrichment for gifted students. For further information about the RAGE "Resource Utilization Kit," contact--Project Director Judy Williams, Macon County Schools, P. O. Box 1029, Franklin, NC 28734 (704-524-4414).

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PART IV

DISCOVERING APPLICATIONS

CHAPTER 13

PERSPECTIVES FROM PRACTITIONERS

REACTION 1

Marsha Cameron

The title of the 1983 AETS Yearbook, Teaching Children Science: Changing Adversity into Advocacy, clearly states that the intent of the book is to provide incentives for teachers and for all who are involved in elementary school education with respect to improving the status of science teaching. The yearbook addresses issues of significance that face today's elementary school science educators. It addresses the needs of professional science educators from undergraduate pre-service teachers and/or researchers to those responsible for policy making and implementation.

The crisis status of science teaching is based on several specific factors. The major factors identified the yearbook were:

1. the changed status of science teaching--reversion to pre-National Science Foundations efforts,
2. the return to non-investigative, textbook-based programs,
3. the impact of "back to basics" and the reduced status of science teaching,
4. the view of science as a subject separate from the essentials of a "good" elementary school program,
5. the attracting and retaining, of energetic, competent elementary school teachers of science,
6. the failure to view science as a vehicle for the development of reasoning,
7. the lack of an acceptable model with direction and focus for science teaching in the elementary school,
8. the less than adequate financial support for an effective elementary school science program, and
9. the lack of appropriate and effective views of modern technology in elementary school science teaching.

In addition to defining the crisis in elementary school science teaching in general terms, the yearbook authors provide specific suggestions for successfully responding to those issues. Some recommendations for improving elementary science teaching were:

1. Evaluate earlier developed national science curriculum projects, selecting from them the most valid concepts, learning theory, teaching methods, materials, and activities.

2. Re-establish questioning, investigative approaches to the students' development of conceptual understanding, and reasoning ability.

3. Employ, in appropriate and effective ways, modern instruments of technology, such as computers, in the instructional program.

4. Incorporate science as a "basic" in an interdisciplinary approach to the intellectual development of the child. Specifically, science was recommended as a vehicle for learning reading, writing, mathematics, and the social sciences.

5. Improve those conditions essential to personal and professional satisfaction of elementary school teachers including such measures as providing science specialists and resource teachers and having a separate certification in science for elementary school teachers. Provide identity, support, and reward to those recognized as competent, successful elementary school science teachers.

6. Develop a model for guiding the continuing development and evaluation of science curricula and instructional programs by using the best information from research and experience in the areas of learning theory, the natural sciences, and societal needs.

7. Encourage and actively promote greater financial support by providing an elementary science program essential to the national interest and to global issues.

As an elementary school practitioner, I see these recommendations as being valid concerns of elementary school teachers. I accept the validity of these proposals. Our failure to act on these concerns has collectively contributed to the crisis in elementary science teaching. Arguments suggesting these positions have been identified and described in the 1983

AETS Yearbook. Given adequate support and leadership, the implementation of these recommendations would vastly improve the achievements of the elementary school student.

Anyone seriously interested in improving the quality of science teaching in the elementary school will benefit from Teaching Children Science: Changing Adversity into Advocacy. The pre-service teacher will gain an excellent view of the changing status, approach, and content of elementary school science. The in-service teacher will acquire suggestions, activities, and a rationale for science teaching in the elementary school. The curriculum supervisor will gain a valid and viable view of science in the elementary curriculum. The administrator will realize the importance of science as a primary area in the elementary curriculum. The legislator will see the urgency of solving the crisis in science education. Parents will value science teaching by providing support for a satisfactory scientific literacy level for all elementary children.

An area of much concern to the elementary school teacher of science, that was not emphasized in the 1983 Yearbook, is the pre-service and in-service training of the elementary school teacher. Surely much of the child's performance is a direct function of the competency and energy of the teacher. Given the proposed role of science in the elementary school curriculum, many teachers are inadequately prepared to allow science the role that it can and must provide in elementary education. Serious attention at the pre-service level should be given to developing a full understanding of the learning theories, the content, and the methodology of programs such as SCIS, SAPA, and ESS.

Both pre-service and in-service teachers need to become comfortable with the idea of learning science and facilitating the science learning of children. However, this will only come with a sense of self-confidence that is developed through proper professional and academic preparation.

As an elementary classroom teacher, the AETS Yearbook has made me aware of:

1. the need for a change in attitude toward science in the elementary school,

2. the value of an expanded role of science in the curriculum,

3. ways to incorporate science other content areas,

4. ideas for coping with my chosen profession, and

5. community resources and their relationship to science teaching.

Specifically stated in the book were items that would be of immediate help to individual teachers such as:

1. lists of goals to be attained by elementary school students, including disabled learners;
2. models for instruction to be used in the teaching of science;
3. factors in an individual's personality that might indicate teaching success;
4. specific suggestions for up-grading the elementary school science program;
5. lists of science activities matched to intellectual levels of students' development;
6. an example of an eco-centric curriculum model for teaching environmental concepts,
7. lists of energy concepts and a brief explanation of each, and
8. a model unit entitled Land--A Primary Resource, to be used as a guide for unit teaching in grades four through seven.

In summary, the 1983 AETS Yearbook provides a collection of compatable arguments and justifications for anyone concerned with the quality of science teaching in the elementary school.

REACTION 2

Sheila M. Jasalavich

Changing adversity to advocacy is the focus of the 1983 AETS Yearbook on elementary school science education. The contributing authors have: described the current adverse status of elementary science education, stressed the importance of fostering thinking skills through science experience, addressed the importance of a multidisciplinary approach to the teaching of science at the elementary school level, and acknowledged the importance of students' developmental levels and how they learn best at these levels. The authors addressed the fundamental role of the elementary school teacher and his/her influence on children's science experience and models of teaching. Educational technology, environmental concerns, special education concerns, and cultural concerns were also discussed. Each issue is important in relation to the total picture of elementary school science education today.

My comments will focus on three concerns:

1. the importance of fostering thinking skills through science experience,
2. the fundamental role of the elementary school teacher and his/her influence on children's science experience, and
3. the need for a multidisciplinary approach to the teaching of science.

These factors are the key to success in changing adversity to advocacy in elementary school science education. In order to succeed, we as educators must strive to realize the educational objective of fostering thinking skills at all levels. The teacher is the primary facilitator of this objective at the elementary school level. Therefore, successful implementation at the elementary school level depends on the teacher. Thinking skills are multidisciplinary tools. A multidisciplinary approach to the entire curriculum reflects the nature of real-world decision-making.

The yearbook authors identify and underscore the monumental importance of fostering the development of thinking skills. The development of thinking skills is not a new objective or unique to elementary science education. The desire to understand and the quest to explain one's world is centuries old. The responsibilities of educators, be they teachers or parents, to cultivate the decision-making skills and logical reasoning of children has long been an awesome and challenging task.

John Dewey eloquently stated:

> A man may have a good deal of cultivation, a good deal of information, correct information ... about things, but if he has never made a first hand acquaintance at some point with scientific ways of dealing with a matter, he has no sure way of telling the difference between all-wool knowledge and shoddy goods (1916, p. 2).

Dewey's statement argues that thinking skills are essential tools for members of society.

The human condition seriously affects the reality of fostering thinking skills through elementary science experience and education in general. We as educators, often do not practice what we preach.

Shymansky and Green suggest that science experience exemplifies the search for order underway as human beings apply and exercise thinking skills. Shymansky and Green, Cohen, and Betkouski all indicate that if elementary school science educators are to assume their rightful role as facilitators of children's search for order, they must first identify and experience the process skills themselves. A great place to start is by posing questions about the world around you and devising activities to find your own answers.

Shymansky and Green and Cohen point out that if prospective teachers learn science as a collection of unchanging information, they will most likely teach it that same way. I might also add that if elementary teachers are taught, for the most part, in teacher education programs via the didactic lecture approach, it will be most difficult to convince them that there are other effective teaching styles. Teacher educators should model the desired teaching styles.

Pratt's (1981) synthesis of research identifies the elementary school teacher as the single most important factor in determining whether an advocacy position toward science teaching exists in the elementary school classrooms today. As an elementary educator who has taught science at the second, third, fifth, and sixth grade levels, I wholeheartedly underscore the fact that advocating the importance of science experience at the elementary level is a fulfulling yet frustrating experience. As noted by Betkouski, the elementary school teacher's concept of his/her role as a science educator and his/her needs as a person and educator must be addressed.

Pratt (1981) suggests that the key to advocacy of elementary school science experience is to take the developed curricula and resources and devote the next twenty years to implementation. Since the teacher is, in the final analysis, what makes or breaks the reality of science experience in the classroom, I will focus on factors that influence elementary school teachers of science.

Trojcak and Shymansky and Green indicate that numerous studies identify elementary teachers as a group ill-at-ease with teaching science. It should be noted that there a few elementary school teachers who do not fit this stereotype and who are providing students with positive science experiences. They are an important yet unrecognized resource for advocacy.

Betkouski suggests improving the elementary science educator's self concept through DARE charts. This exercise provides an opportunity to deal with science anxiety. Shymansky and Green suggest that inquiry exercises with everyday things can enhance the elementary educator's awareness of how useful process skills are.

Betkouski points out that growth depends on a strong self-concept and on the opportunity to grow. Therefore, it is imperative to provide pre-service and in-service teachers with positive, hands-on science experiences. All too often, teacher training for elementary science educators has involved a brief elementary science methods course that was "farmed out" to various science departments. The degree to which process or thinking skills are fostered in elementary school science methods courses varies. The amount of useable science content gleaned via the "farmed out" approach is questionable.

Shymansky and Green state that no minimum amount of science course work is a prerequisite to teaching good elementary school science. As an elementary science educator who has been through a graduate program in elementary science education where students are "farmed out," I question the usefulness of information overload. The acquisition of pertinent science content information in conjunction with inquiry-based courses for elementary school teachers is far more valuable and practical. Positive, hands-on science experience can lead to positive attitudes towards science teaching.

The needs of elementary school science educators are different from the needs of other students in college level science courses. That is why the number of science content courses taken does not necessarily correlate with successful elementary science teaching.

Pratt (1981) indicates that good, practical in-service workshops are few and far between. He further states that the in-service programs that capitalize on extensive instructional materials are viewed as useless by teachers because the same conditions and materials do not exist in their own classrooms.

Outstanding elementary school teachers who provide positive science experiences for their students are perfect resource people to utilize within the education system. Local and statewide workshops given by teachers for fellow teachers are very well-received and useful. Pratt (1981) indicates that teachers are other teachers most valuable resource. Exemplary elementary school science educators within systems are truly aware of the limitations and problems within their own system. They are able to share ideas which overcome these deficits. Their activities can be viewed as workable by other teachers because, for the most part, they have been field-tested within the same system. Cooperative efforts to provide practical in-service workshops can be enhanced when exemplary elementary school science teachers join forces with personnel from teacher education centers. As noted by Betkouski and Cleminson, et al., long-term in-service programs are the most useful. They can reinforce positive experiences that teachers have and deal with problems that may arise.

Pre-service and in-service courses which focus on the multidisciplinary approach to elementary school education can be very useful. Brainstorming, trying out ideas, and evaluating multidisciplinary programs as in-service instruction is a creative alternative to in-service presentation given by experts whose sole purpose is to instill and impose. Teachers as a group can generate inquiry-oriented experiences which focus on science, reading, language arts, social studies, mathematics, music and art. They can use Simpson and Butts dialogue between reading, science, and mathematics consultants as a starting point in the identification of common objectives.

We as educators must meet the challenge of changing adversity to advocacy for teaching children science. Fostering the development of thinking skills, valuing the fundamental role of the elementary school teacher and his/her influence on children's science experience, and employing a multidisciplinary approach to elementary education are all stepping stones for advocacy. We as elementary school educators and educators of teachers must take a hard look at ourselves and begin to change from within. Modeling teaching practices or "practicing what we preach" is fundamental if we are to positively influence others--be they our students or other teachers.

Recall the old saying, "You can lead a horse to water, but you can't make him drink." This may be true, but if you can get him thirsty enough--the rest will be easy! The challenge awaits!

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REACTION 3

Suzanne Z. Kelly

When you walk through the woods, do you see the forest or the trees? Which is more important: where you have been or where you are going? Does satisfaction come from taking the journey or from arriving at a destination?

Responses to these questions would probably be as individualistic as responses to walking through the 1983 AETS Yearbook and gaining greater perspective on science teaching and science learning. The views are varied. Though authors tend to agree on the present status of elementary school science, they also provide a hope that floudering in the woods is not a permanent state, that with the proper map, we will no longer be disoriented.

VIEWING THE FOREST

Various reasons are given for the declining emphasis on elementary school science. The best analysis is done by Doris Trojcak in Chapter 1. While authors offer various supported arguments, common pathways occur in the forest:

1. emphasis on "Back to Basics" versus "Forward to the Future"
2. emphasis on "Concepts" versus "Processes"
3. emphasis on "What to Teach" versus "How to Teach It"
4. emphasis on "Idealism" versus "Realism"

Though most authors identified the rush of "back to basics" as an educational trend that has greatly affected elementary school science, optimistic arguments were also given for this trend to change. The proverbial pendulum no doubt will swing again. However, the extent of damage that will be done in the meantime remains a concern. Some authors felt that we never left the basics. Others analyzed the relationship between the 3R basics and science learning. Still others argued that with an issued-oriented curriculum, it would be forward to the basics. At any rate, the concern of school districts for standardized testing on reading and mathematics is presently adversely affecting the amount of money, time, and emphasis being given to science education. Whatever the relationship is between science and the "basics," most authors agreed--science is no longer top dog!

Terminology relating to science learning was extremely varied. Some authors referred to content. Others made distinctions between concepts and processes. Others dissected concepts into exploration, invention, and application. Still others referred to skills, ideas, goals, objectives, factual knowledge, conceptual schemes, beliefs, searches, instruction, infusion, products, problems, explorations, applications, etc. The terms and definitions seemed almost endless. A common theme, however, was the argument for more than factual information to be presented and learned. All authors seemed to recognize that knowledge, in and of itself, is not enough in the area of science, and knowledge, without relationship to the learner, is meaningless. The processes, critical thinking skills, problem-solving skills, or whatever term you wish to argue, must be an integral part of science learning. Somehow students must also internalize the concepts and the processes and apply these with emphasis on personal values and even on global concerns.

Although the intent by the authors was to limit their emphasis to science teaching, in many cases views on the total educational curriculum were expressed. What to teach and how to teach it was considered in all chapters. Textbooks, activity-based kits, and combination approaches were discussed Some authors advocated totally new curriculum structures--such as comparisons of mathematics, reading, and science skills; interdisciplinary plans; infusion of science with people issues (ecology, environment, energy); reversing the traditional sequence to teach global concerns before individual awareness, etc. Authors agreed that science teaching must have meaning, whether it be through activity-based, hands-on type materials, or other methods which would help the "abstract" become more "concrete." Such methods employ computers, outdoor adventures, regional community resources utilization, and simulation techniques.

Idealism and realism were other major themes. Most authors tried to analyze where we are in science teaching and then make a comparison to where we should be. Most agreed that the range between the two is becoming wider. Some authors gave reasons for this gap and others expressed criticism for the decline in the quantity and quality of science teaching. Still others stressed what they felt the ideal programs should include.

VIEWING THE TREES

This chapter is to be a perspective or a view of the relationship of the parts of the whole. Pehaps it is time to view the trees in the forest. Again, the best analysis is in Chapter 1. Doris Trojcak captures it all. Other authors provided supportive information. Let us view common species growing in the forest of science education.

1. emphasis on role of the teacher

2. emphasis on time to teach

3. emphasis on materials to use

The authors agreed that the role of the teacher is extremely important in the teaching of science. Obviously! However, most authors delved into related factors, such as teacher's interests, awareness, background of experiences, confidence, and curiosity about science. Much research was reported concerning the importance of teacher expertise in the area of elementary school science, not as dispenser of knowledge but as leader in search of meeting the needs of children.

The closer we look at an elementary school science program the closer we must look at what actually should and does take place in the classroom (indoors or out!). The educator who develops intricate models to explain how children think may stimulate the thinking of the children's teachers.

Projects or models which encourage quick change are dangerous. The purpose and the process of the change should be clear and concise. For a practitioner to throw away topics of "plants," "animals" and "rocks," for "environment and you," "energy and the world food supply," "population and pollution," means a certain amount of expertise and energy must be expended to incorporate all ingredients in a sequential manner for meaningful learning to take place. The theme of "scope and sequence" is not "in" this year but for the practitioner it is imperative. What do I teach and when do I teach it? A classroom teacher feels responsible for students although the students spend much of their day with other teachers. What did they learn last year? What will they be expected to know next year? Any synthesizing or infusing of content must be clear and concise to meet the practical needs of teaching as well as the idealistic needs of learning!

The yearbook authors recognized that not much time is being spent on science. Various reasons were given. Acceptable time allotments were also suggested. The major theme, however, was that the curriculum clock ticks away and time is taken for many areas besides science. While some authors suggested the infusion of subjects so the multi-disciplinary approach would cover all educational objectives, other authors seemed to stress the need for science emphasis without it getting lost under additions to the curriculum. Time constraints pertain not only to the learning of science but also the preparation time a teacher needs for the teaching of science must be considered. As concerns for the individual child (the talented and gifted, the educably mentally retarded being mainstreamed, the learning disabled, the physically disabled, even the normal!) become greater, and the demands for the role of the teacher become greater (psychologist, parent-figure, disciplinarian, recycler, etc.) and demands for finances become greater (fewer materials, larger classes, less planning time, etc.) then EVERYTHING that can be done to assist the teacher, MUST be done. Time becomes critical. The less time taken in "getting ready to teach" means more time in teaching. Time must be used to maximize the greatest learning on the part of students.

The yearbook authors presented a variety of materials to use, both for students and for teachers. Various texts were analyzed. Models were suggested for the selection of science goals. Lists of objectives and a variety of helpful hints were mentioned--all for the intent of improved science learning.

VIEWING THE FORESTS AND THE TREES

Perhaps in any walk through the woods there is need to see both the trees and the forest. Natural wonder, aesthetic awareness, and personal growth can come through both the looking at the parts and the fitting of the parts into a larger whole. The 1983 AETS Yearbook can do both.

A critical look at science education cannot be totally separated from a critical look at total education. When we view the whole, we must also take a look at society. Although the purpose for these authors was to look at science education, it was not always viewed as part of the total picture. We will never truly progress in science education until we truly progress in education. We can begin with the part or we can begin with the whole, but we must view both. Do I teach science? Or do I teach people? I do both. Are we so absorbed in science teaching that we neglect the emphasis of science learning? The arguments for slices of the curriculum pie are important, yes, but a decline in any one of them affects the whole. Neglect of reading skills will affect science. Neglect of science education will affect problem solving ability of students. Neglect of reasoning skills by students affects their interactions with society and their environments. The parts and the whole are important.

BARKING UP THE WRONG TREE

This yearbook has much value for many people. However, we are barking up the wrong tree, unless we make certain of the following:

1. The right people must receive messages that are being sent.

2. We must learn from the past so we progress in the future.

3. The idealistic views from the "college community" must meet the realistic situations of the elementary school classroom.

First of all, the Yearbook must be read by the right people. It should be read by college and secondary science educators. In it they will find suggestions and theories with which they can agree and disagree. Secondly, it should be read by all those involved in teaching elementary school science--teachers, student teachers, elementary principals, science coordinators, curriculum directors, and boards of education. They will find the yearbook both challenging and rewarding. It should be read by the manufacturers and publishers of science materials for elementary science programs. No one is more guilty of perpetuating the discrepancies between the idealistic and the realistic experiences which children have than the industries which supply the materials. Although it is the teacher who ultimately conducts lessons in the classroom, it is the publisher who provide the help or hinderance for the busy, busy classroom teacher.

Some of the same criticism that is suggested by the authors for the decline in science teaching may also be attributed to some of the new approaches suggested by the authors. Eco-centric approaches, infusion of multidisciplinary goals, etc. will be no different from the "alphabet curricula" if we do not learn more about the needs of teachers. Some authors mentioned teachers' lack of college background courses, job survival based on student performance on reading scores, or overcrowded demands on teacher time as reasons for decreased science teaching. The new approaches do not seem easy to comprehend, free from administrative .or community pressures, or much of an ease on teacher time. Again, the idealism of science teaching and the realism of science learning may be quite some distance apart.

We are barking up the wrong tree if we continue to emphasize processes as though we are eliminating the desire for factual knowledge. It is that old pendulum swinging again--textbooks to activity-based science back to textbooks. The "alphabet curricula" were difficult for teachers to "get their teeth into," even if they loved getting their "hands on it." Let's not make the same mistakes with new approaches or even new textbooks. Third graders do not have time to discover the wheel. They can be told that the wheel is a simple machine. However, they need time to explore the uses and applications of the wheel. They also need the skills by which they can investigate. Who knows? Perhaps one of them will invent something BETTER than the wheel! Teaching factual knowledge is not wrong. However, it does not comprise a total science program. Teaching students to observe and predict is not wrong. However, it does not mean skills can be learned in total isolation of concepts. We must learn from the past and meet both the needs of teachers and learners.

There is no reason why the practitioner cannot learn from the research and the expertise offered by the college community. There is no reason why the idealism expounded by education and education methods courses cannot also reflect the realistic world of the elementary school classroom. The most lofty lesson plans in the world have not reached their potential until they have reached the minds and hearts of students. There is no reason why the materials generated by publishing companies cannot be more adept at meeting both the needs of teachers and learners!

We are truly barking up the wrong tree if we can not look at the parts and the whole. It is important to know where we have been in education and where we are going. Let us all take satisfaction in making the journey of elementary science a continued search for excellence.

VIEWING THE FOREST, THE TREE, AND THE BARK!

Come walk with me in the woods. Absorb the peace of the forest. Wonder about the growth of the tree. Revel in the roughness of its bark. Care about its environment.

Then go home and get a friend . . . and walk in the woods.

CHAPTER 14

PERSPECTIVES ON PROFESSIONAL GROWTH

Bernard W. Benson

and

Thomas E. Bibler

INTRODUCTION

Few texts in the field of education (including yearbooks) are provocative to the point of capturing reader attention from beginning to end. This chapter provides teachers with a format to follow when using this yearbook. The 1983 AETS Yearbook is intended as a text for the in-service education of elementary school personnel. The approach used in this chapter is adapted from McCarthy's (1980) 4MAT System. This system applies style research (see Berger, 1981) and split-brain research findings to an instrustional format that assures a variety of types of learner activity. The validity of such research notwithstanding, we would probably agree with Berger (1981) that "teachers appreciate a wide variety of styles and activities . . . " (p. 72).

McCarthy's model identifies four major types of learners respective to learning styles--innovative learners, analytic learners, common-sense learners, and dynamic learners. Innovative learners are primarily interested in personal meaning. Analytic learners are interested in facts. Those who are characterized by wanting to know how things work are the common-sense learners. Lastly, dynamic learners prefer self-discovery. The marginal headings used in organizing the activities for this chapter correspond, in order, to the four learning types described above. Figure 1 characterizes each learning type in more detail.

The rationale behind the 4MAT System assures that all learners are given the opportunity to experience each learning style. The four quadrants of the 4MAT System are each divided into segments representing activities attending to right and left brain functioning. In the activities that follow no attempt has been made to separate activities on the basis of hemispheric functioning simply because space would not allow this degree of elaboration. Some of the activities emphasize right brain function by stressing more intuitive approaches, whereas others stress the analytical qualities of the left brain. According to McCarthy (1980) the purpose of education should be to, "teach the 'whole brain' intellectual and intuitive, mind and heart, content centered and student centered" (p. 77). Such approaches are as valid for teachers as they are for students.

We have provided activities for each chapter of Parts I and II. A similar approach could be applied to Part III. It is recommended that a science supervisor or university-based science educator be available to provide leadership or at least expertise where appropriate. Many of the chapters pre-suppose general knowledge in science education that may require explanation or clarification.

Innovative Learners (Integrating Experience with the "Self")

- seek meaning
- personal involvement
- function through social interaction
- innovative and imaginative
- learn by sensing/feeling and watching

Analytic Learners (Concept Formation)

- need to know what experts think
- more interested in ideas and concepts than people
- thorough and industrious
- prefer traditional classrooms
- learn by watching and thinking

Common Sense Learners (Practice and Personalization)

- seek usability
- need to know how things work
- edit reality
- need hands-on experiences
- learn by thinking and doing

Dynamic Learners (Integrating Application and Experience)

- seek hidden possibilities
- learn by trial and error, self-discovery
- enrich reality
- like variety and excel in situations calling for flexibility
- learn by doing and sensing/feeling

Figure 1. Learning Styles Characterized (McCarthy 1980, pp 37-43 and 49).

1. SCIENCE TEACHING TODAY'S VIEWS[1]

Integrating Experience with the "Self"

Orientation: Have you ever been labeled? Have you ever been labeled inappropriately? Have you ever agreed with your label but wished you had another label? Consciously or subconsciously, we label our associates and they us. Understanding your "labels" is an initial step in coming to grips with why the status of science teaching is as it is today.

Work in groups of three to six teachers. If you are not enrolled in a formal in-service program, try this activity with a group of your colleagues. Little advanced preparation is needed or recommended.

Procedure: Prepare a container with several slips of paper, each with one letter from A-D. Each participant should select one slip. The letter corresponds to the "type" of teacher you will play in this simulation. Tell no one your "type." Read the brief description of your "type" as stated in the section of Chapter 1 entitled "Typecasting Teachers." Also read the expanded description of your "type" in the succeeding paragraphs. Read only the description of your "type." Represent your "type" in a discussion that begins as follows:

> "As a school board member I fail to see why there is all this fuss by some parents over science teaching. Science is part of our elementary school curriculum. We adopted new texts last year. What more can they expect? Don't you agree?"

At the end of the simulation you should be able to

- defend your "type" in a 15 minute discussion,
- identify group members who represented their "type" most effectively,
- identify each teacher by "type" based solely on the simulation experience
- determine why some roles were easier to play than others, and
- discuss the implications of not having all roles represented in the simulation or in an actual confrontation with a school board member.

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[1] This section is to be used in conjunction with Chapter 1 in this yearbook. Subsequent headings refer to subsequent chapters in the yearbook.

Outcomes: By the end of this activity you should have assessed the degree of diversity represented by your colleagues with respective to science teaching styles and attitudes. In addition, you should now be more sensitive and understanding of the attitudes of other science teachers who are of a different "type."

Concept Formation

Orientation: The outcomes of this section reflect activities that will provide you with a sense of the major concepts presented in this chapter. Select from the following activities those that interest you most. Share your findings. Read Chapter 1 before beginning this activity.

Procedure:

1. Construct an example in the context of science of the application of each of the following terms: inferring, hypothesizing, analyzing, synthesizing, evaluating, and problem solving.

2. Construct a list of those factors that contribute to ineffective science teaching in today's elementary schools. Identify from this list a set of trends in science teaching; e.g., from "hands on" science to "hands off" science.

3. Identify the positive factors affecting science teaching today.

4. Describe a learning situation in which you experienced disequilibrium. How often do you leave your students with similar situations? Is this good or bad?

Outcomes: This section should leave you with a sense of the factors that are operating with respect to what and how science is being taught today in elementary schools. You will have to accommodate to those concepts that are new to you. This would be an ideal time to examine available resources for teaching science, as science methods texts and journal articles.

Practice and Personalization

Orientation: The purpose of this section is to allow you to apply what you learned above to different contexts.

Procedure:

1. Classify the teachers in your school by "type." Use code names like "Myra Blabber" or "Joe N. Query." Describe the style of each teacher. If you are working with teachers from other schools or other school systems, compare your results. What generalizations can you construct?

2. Examine instructional materials from Elementary Science Study (ESS) Science--A Process Approach (S--APA), or Science Curriculum Improvement Study (SCIS). Select an activity appropriate for your class. Teach the activity and share this experience.

3. Compare science textbook programs written before the development of the National Science Foundation curricular materials to recently published science textbooks. Summarize your findings. Do your findings concur with the data presented on p. 9 of this yearbook?

4. Review your school system's policy on science teaching with particular reference to the impact the teaching of "basics" has had upon science teachers. Compare this policy with actual practice.

Outcomes: The above activities should reinforce what you learned under the Concept Formation section.

Integrating Applications and Experience

Orientation: You are asked to design and construct procedures based on the skills and understandings that you developed in the previous activities. The activities described below encourage creativity and insight on your part.

Procedure:

1. Develop a position statement based on the priorities listed on pp. 10-11 respective to why science instructions should be emphasized in the elementary school. Try to influence others by publishing your position in a local paper, association newsletter or journal, or by presenting your position to your school board.

2. Examine the resources available in your school that are available to you for teaching science. Assume you are given $500 to spend on science teaching. Propose how you would spend the money. Include a detailed budget with your proposal. (Rethink this proposal after you have studied several other chapters in this yearbook.)

Outcomes: By this time you should know yourself (your "type") and your colleagues better than you did at the beginning of your study of Chapter 1. You should not only have a sense of the historical development of science teaching but more clearly understand the current status of science teaching and your role in promoting its advocacy. However, you may have deluded yourself into thinking that you are now in a position to act in the cause of promoting science teaching. Chapter 1 should have left you with good intentions. Your study of the remaining chapters should make your intentions good.

2. SCIENCE TEACHING GOALS: DIRECTED AND ELUDED

Integrating Experience with the "Self"

Procedure: Select a controversial issue--abortion, creationism vs evolution, tuition tax credits, prayer in schools, the three-martini lunch, nuclear power generation. Assess your position. Now write a "letter to the editor" arguing against your position. (That's correct, against your position.) We could label this activity, "Being Your Own Antagonist." Push yourself, allowing no more than 30 minutes to compose your letter. Complete this activity before you read the Orientation section.

Orientation: Issues are not always clear and concise, pro and con. We often do not fully understand our own position on a particular issue although we think we do. We consider ourselves reasonable, but we are often not reasoned. Often we would be better off reserving judgment, but we do not. At best we are capable of changing our minds or taking stronger positions. Sometimes issues are not as they appear (e.g., Did we err in listing Procedure before Orientation or was the reversal intentional?).

Procedure: Now discuss or reflect on how it felt to play a role counter to your beliefs. Discuss or reflect on the impact of your own propaganda on your previously stated view. Did you alter or change your original position in any way? Discuss or reflect on how the role you were asked to play is not so different from the roles you are often expected to play in real life. Have you ever felt constrained--unable to say what you really mean or mean what you had to say?

Outcomes: These activities set the stage for what you are about to experience. They are intended to establish the need for realistic and meaningful goals for science teaching.

Concept Formation

Orientation: Do you know what it is like to experience an odyssey? You are about to find out through your experience with Chapter 2, "Science Teaching Goals: Directed and Deluded." This section of activities is designed to minimize the trauma associated with such an experience. If you seek structure (direction) from the beginning, you are less likely to wander aimlessly for too long at any one time. Study the concept map located at the beginning of Chapter 2. As you perform the following activities, refer back to this map often.

Procedure:

1. Make several copies of Figure 4 (see p. 21). Follow Cohen's suggestion and "fill-in" your perceptions as you make your way through the chapter.

2. Identify from the text those qualities of models that are appropriate to understanding the nature of science and those that are appropriate to understanding the nature of how to teach science.

3. In the context of the section entitled "What Stereotype of Children Do We Use to Develop Science Teaching Goals?", construct a list of ten attributes of such a child. Compare your list with the list of other teachers. Translate these statements to their appropriate place in Figure 4 (p. 21).

4. List the science teaching goals explicitly stated in Chapter 2. Equate them with the list of goals found in Figure 7 of Chapter 2.

5. Answer the question "Can Adults Separate Science Teaching Goals from Indoctrination?" Is it really necessary to involve students in the process of identifying goals?

6. Figure 6 in Chapter 2 lists six examples of the "concepts" of "science." Interpret each statement. Work in groups if possible. Identify those statements that you can relate to best. Lastly, discuss whether your family physician is a technician or a scientist.

Outcomes: These activities represent a search for substance and meaning. When you finish this section, you should have developed a mental structure for those conceptual areas represented in the above activities. There are several other concepts developed in Chapter 2 that are not addressed. Identify and discuss these concepts if time permits.

Practice and Personalization

Orientation: Chapter 2 provides a wealth of strategies and assumptions useful to teachers involved in defining science teaching goals. Only a few of these strategies and assumptions will be reinforced through the activities in this section.

Procedure:

1. Review your study of models once again. What model or models do you use in teaching children science? If you are working in a group, help one another develop your models diagramatically. Label your models, e.g., the investigation model, the smorgasbord model, the regurgitation model. Defend your model. Have others defend it. Refute your model. Have others refute it.

2. Examine Figure 5 in Chapter 2 which lists children's explanations of various science concepts. To help put these statements in perspective, we suggest you read Chapter 8. Based on your own experiences add to this list.

3. Chapter 2 stresses the importance of laboratory instruction in the achievement of some science teaching goals. Discuss a variety of science lessons with your colleagues. Identify the laboratory component of these lessons. What is meant by laboratory instruction? Become sensitive to Cohen's remarks on p. 35. Expand your concept of laboratory.

4. Confusion has resulted concerning the relationship between science process skills and the content of science. This issue is discussed on pp. 35-36. Generate a list of false assumptions based on what you read on these pages. Discuss the list with your fellow teachers. Construct a list of corrected assumptions demonstrating the relationship among science processes and between science content and science processes.

Outcomes: You should now be in a position to formalize science teaching goals for your students, for your school, or for your school system. After completing these activities you should have a perspective on science teaching that is based on a rational model, that is sensitive to the many ways children interpret the world, and that provides an expanded view of what science teaching is all about. There are many other strategies addressed in Chapter 2. You are encouraged to invent ways to accommodate to them and to surround them with experience to reinforce their meaning.

Integrating Application and Experience

Orientation: This activity will result in a formal statement of science teaching goals. This statement should consist of a rationale for science teaching and a specific list of goals. Both should be personalized to your particular teaching situation. This can be an individual or group activity.

Procedure: Review Figure 4 in Chapter 2. It should contain considerable information by this time. Also review the concept map for this chapter. It should have far greater meaning to you now than when you started working with this chapter. (If this is not the case, then we suggest you write Mike Cohen a letter.) Your rationale should be concise and should reflect your values with respect to how you view science and the importance of science instruction to the learner and to society in general. Set the clock. Give yourself about 15 minutes. Generate as many goals as you can. Now refine and revise your goals.

Examine Figure 7 in Chapter 2. This list of goals could serve as a "model" for you to use in expanding your list of goals. Do so. Now refine and revise your list.

Outcomes: How do you "feel" about your statement goal? You should by this time be able to think of your goals for science teaching as a creed and ultimately as a manefesto. If you cannot do this, don't worry. This confirmation will slowly grow as you study other chapters of this yearbook. Just don't delude yourself in the process.

3. VALUING SCIENCE CONTENT: SCIENCE IS A BASIC WE ALL CAN DO

Integrating Experience with "Self"

Orientation: The following activities are designed to enhance your appreciation of and ability to use this chapter. It is assumed that you have read the chapter and are attending an in-service workshop with other elementary teachers. Many of the activities call for a group response. (If you are alone, do the activities that you can, and do your best to "think through" those designed for the entire group.) The large group should be divided into study sections no larger than seven teachers and no smaller than four.

Procedure:

1. List five science questions that you could investigate based on the location and materials at hand, while you read this Yearbook. Examples:

(a) Survey other elementary teachers--readers of the yearbook--to ascertain the order in which they read these chapters; the time at which the reading was alone with respect to when the book was received, etc.

(b) How was the paper of the yearbook manufactured?

(c) Estimate the "environmental cost" of the yearbook.

(d) List three things you have done or have failed to do this month that are positive evidence of valuing science content.

(e) List three things you have done or have failed to do this month that are negative evidence of valuing science content. Share and discuss your examples with one other elementary teacher.

2. Outline and assign priority to the three main premises held by Shymansky and Green in Chapter 3. Write one question in connection with each premise that you would like to ask Shymansky and Green if they were present at your in-service workshop. Share your questions within your study section. How similar are the questions? Why are there differences? Can the group provide satisfactory answers to all questions? Note all puzzling questions for next activity.

Outcomes: These activities are meant to emphasize the pervasiveness of science and help you clarify the major thrust of the chapter.

Concept Formation

Orientation: Setting and grouping same as for the integration segment.

Procedure:

1. Meeting as a whole, list all the puzzling questions from each group on butcher paper. (If there are no puzzling questions, have each group list its most interesting questions.) These questions are posted where all can see. Each study group then orders the questions according to their importance to valuing science content. Each study group then design a strategy for obtaining answers, or at least additional data, on each of their top three questions. These strategies are then shared with the entire workshop.

2. Re-read the highlighted statements in this chapter. Do they adequately reflect the science content concerns of your

workshop as indicated in the "puzzling question" activity above. Each study group is to rewrite the highlighted sections so that they are tailored to fit this workshop. Report all additions and omissions to the entire group and give reasoning for same.

Outcomes: These activities are designed to allow the workshop participants to demonstrate a valuing of science and to interrelate the views of the authors of the chapter with their own and with the views of others attending the workshop.

Practice and Personalization

Orientation: Same setting

Procedure:

1. Write a complete lesson plan (including a plan for evaluation) for one of the science activities based on common phenomena presented in this chapter. Present and discuss this in your study group.

2. Develop a complete lesson plan for a science activity based on a common phenomenon that has not been specifically mentioned in this chapter and that you could implement in your own classroom in the next week. Share the plans in the study group--revise as necessary. (Duplication service should be provided at the workshop so that all teachers of a given grade level could have copies of all the plans developed for their grade level).

Outcomes: These activities should provide reinforcement for the concepts in this chapter by requiring teachers to apply them to the classroom. In this application the teachers are encouraged to apply what they learned during the concept formation activity sequence.

Integrating Application and Experience

Orientation: Study groups reconstituted by grade level.

Procedure:

1. Each individual analyzes the lesson plans for his/her grade level and develops a proposed sequence and rationale for this choice. Potential implementation problems and solutions are hypothesized and shared in study group.

2. Each study group develops a written evaluation appropriate for its activities. A date is established whereby the activities will have been tried and evaluated. All evaluations are to be sent to the study group chair who will compile and circulate results to all members.

Outcomes: Teachers will have enhanced their ability to systematically plan a learning project and evaluation. They will have a plan for sharing their results, thereby increasing the liklihood of implementation.

4. VALUING PREPARATION IN SCIENCE METHODOLOGY AND GOALS

Integrating Experience with "Self"

Orientation: Sit back, relax and, prior to reading this chapter, close your eyes and give your imagination free rein. You are in your classroom. The time is ten years hence. You feel especially good about your science lesson because the problems with your science teaching that plagued you in 1982 have largely been solved. You are really looking forward to your class when you remember your promise to the state elementary science supervisor for an article on science in today's classroom. You know that in this day and age no one would expect you to work on the article on your own time. You call for the building science consultant to take over your class and retire to your office to write. Alone in your office you think about the problems of teaching science in 1992-93 and as a preliminary you decide to list the problems as they were in 1982-83.

Procedure:

1. Using the following categories list the problems of science teaching in 1982-83.

(a) Problems of methodology

(b) Problems of teacher training

(c) Problems of teacher motivation

(d) Problems of elementary science goal specification and attainment.

2. Read Chapter 4, pp. 69-70. Compare your list of problems with the problems listed by McGlathery. If you are in an in-service workshop, divide the workshop into groups of seven to ten teachers and combine your lists and the author's list and discuss the relevance of each item on your master list.

Outcomes: These activities foster group interaction skills and they provide a meaningful focus on science teaching problems as seen by both the teachers in the field and by McGlathery.

Concept Formation

Orientation: Read Chapter 4, pp. 73-75. In this section the following questions are examined:

(a) What is science?

(b) What is a scientist?

(c) Why teach science in the elementary school?

(d) What role can science play in developing the elementary student's mental, moral, and physical capacities?

(e) How is science inter-related with societal concerns?

(f) What resources are available for science teaching?

Procedure:

1. In not more than two sentences each, summarize McGlathery's position on each of the questions listed above. Write down your sentences and compare them with those of the other teachers in your group. Create a group consensus summary of McGlathery's position on each of these questions.

2. Look back at the problems your group outlined in the first activity under Integrating Experience With the Self. Can all of these questions be subsumed under the problems you listed? If not explain why or modify your list to include these questions. In your group discuss whether or not the questions aid in clarifying the problems inherent in elementary science teaching.

Outcomes: These activities focus on translation and on evaluation. The concepts of the author are put in the teachers own words and then examined for aptness and for completeness of thought.

Practice and Personalization

Orientation: Setting same as before. Reread Chapter 4, pp.

75-77. Teachers unfamiliar with each strategy should be identified.

Procedure:

1. If possible, one teacher in the group to whom inquiry is new is assigned to develop a brief elementary science exercise based on the inquiry model in the format described by McGlathery as taken from Joyce and Weil. This is presented to the group.

2. One teacher in the group develops an exercise based on the simulation model and presents it.

3. One teacher in the group creates an advance organizer exercise and presents it.

4. One teacher in the group presents a concept formation exercise.

Each of the above exercises is evaluated by the group. Then each of the teachers picks a method and develops a complete lesson plan utilizing it. These are duplicated, organized by grade level, and distributed to the entire workshop.

Outcomes: As a result of these activities the teachers should have at least one well developed teaching strategy to add to their repertoire and should have examples of all the strategies discussed in this chapter together with very practical applications for their use.

*A variety of science materials will have to be provided by the workshop organizers.

Integrating Application and Experience

Orientation: The first activity listed under procedures can be done individually if all the teachers in the group are using different student science texts or the group can be re-organized into small clusters of teachers who use the same texts. The second activity is to be done individually, compiled by grade level groups, and reproduced for all workshop participants. Teachers must bring their texts to the inservice workshop.

Procedure:

1. Each teacher is to take the text she/he is using, determine its classification, (see pp. 79-81) and write a specific analysis with regard to its meeting Goal Cluster I: Personal Needs; Goal Cluster II:Societal Issues; Goal Cluster III:Academic Preparation, and Goal Cluster IV: Career Education/Awareness. Specific page numbers in the student

science text should be cited to support each statement. (If several teachers in the group are using the same materials this activity can become a cluster one instead of an individual one.)

2. Each teacher is to outline the article she/he is writing for the state elementary science supervisor on science teaching in today's classroom, 1992-93. Keep in mind that this article should demonstrate that the 1982-83 problems of elementary science teaching have largely been solved. You might also want to indicate new problem areas, if you feel nirvana has not been attained.

Outcomes: These activities are designed to focus on what the elementary teacher is using to teach science in his/her own classroom and to force an evaluation of this material. It is hoped that this will lead to a change if the material is found wanting. These activities also provide a vehicle for trying all of McGlathery's suggestions together and allow the teacher-participants to make their own statements concerning valuing preparation in science methodology and goals.

5. VALUING THE INFUSION PROCESS

Integrating Experience With Self

Orientation: The following activities are to be done prior to reading this chapter. Answers are to be written and brought with you to the in-service workshop.

Procedure:

1. Choose one of the following roles with which you are most comfortable:

an elementary music teacher
an elementary art teacher
an elementary health/P.E. teacher
an elementary teacher with primary interest in
social studies

In the role you have chosen, write a position statement outlining the relationship of your subject to the rest of the elementary curriculum especially vis-a-vis science.

The in-service workshop should be divided into study groups of between four and seven teachers. Share your position statement with your group.

2. As a group refine the position statement of each member. Make sure each statement addresses:

(a) the relationship of the subject area to enhance student self-concept,

(b) the increase (and necessity for same) of student's conceptual knowledge in the chosen subject area, and

(c) the involvement of students "out-of-school" life with this subject area (the subject areas practical relevance).

Could the school curriculum be enhanced by the abolition of your subject area? Why? Discuss these questions in your group.

Outcomes: These activities are designed to stimulate the teacher's curiosity about the chapter and to provide an imaginative basis for discussion.

Concept Formation

Orientation: Teachers are to read Chapter 5 before doing the rest of the activities.

Procedure:

1. Construct a list of the interconnections Simpson and Butts find existing between reading, science, and mathematics. (Examples--a. all three are "basics"; b. all require being able "to describe things accurately", c. etc.) Compare lists and put together a consensus list for your group.

2. Based on this chapter's usage define each of the following terms: a. infusion, b. reading, c. basic, d. linkage, e. change, f. variable, g. inference, h. hypothesize, i. integration. Which of these terms have definitions unique to this chapter? Do you support these definitions? Why? Discuss and answer these questions in your small group.

Outcomes: These activities should isolate the concepts Simpson and Butts have delineated and should highlight the intent of the authors in terms of the usage of specific terminology.

Practice and Personalization

Orientation: Each of the small groups needs to be supplied with sample Grade Two and Grade Four science materials from a variety of sources. In the Simpson-Butts dialogue the Grade Two science emphasis is on change; in Grade Four the key word is variable.

Procedure:

1. Each group examines the science materials for evidence supporting or disproving the Simpson-Butts characterization of science at these two grade levels.

2. Develop two other terms for characterizing science at these grade levels. Cite evidence from your examination of the science materials to support your choice of terms. Is this kind of simplification useful? Why? Discuss and answer these questions in your small group.

Outcomes: Teachers should find the information in this chapter reinforced by utilizing existing science materials. They should also have personalized their attitude toward Grade Two and Grade Four science by characterizing the science curriculum for these grades in their own words.

Integrating Application and Experience

Orientation: Reconstitute the small groups so that each group has seven members and assign three members to the roles of science, mathematics, and reading consultants respectively. The other four members should represent the art, music, health/PE, and social studies positions they developed in the first activity in the Integrating Experience section. (It is beneficial to have had these position statements previously developed, but if the groups do not work out this way, the position statements could be developed at this time.)

Procedure:

1. Choose a grade level and role-play the discussion of infusion utilizing the chapter and previously prepared position statements. Discuss and answer the following questions in your group: How close does your role-play dialogue follow the dialogue in the chapter? What differences are caused by the addition of the four other roles? Which version, yours or the Simpson-Butts, offers the clearest insights into the elementary curriculum? Why?

2. Assume the role of Mrs. Jackson, teacher at Kingswood Elementary School, and draft a letter to Simpson and Butts explaining what reading their chapter has done for you and your first grade class. Be as specific as possible. Share your letters in your group.

Outcomes: Teachers should be able to analyze this chapter in terms of its usefulness and originality and as a stepping stone for future learning. They should be able to apply what they have learned to a classroom situation.

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